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THE DISASTER AT ST. GERVAIS.

A SUPPLEMENT.

By the Right Hon. Sir EDWARD FRY, LL.D., F.R.S., &c.

THE article which appeared on this subject in the November number of KNOWLEDGE has brought me some letters which appear to me well worthy of the attention of my readers, and with the permission of their writers, and with some slight alterations and additions kindly made by their hands, they appear below.

I am desirous also of availing myself of this opportunity to make a few additions and corrections to my article.

First, I may mention that three papers on the subject have appeared in the *Comptes Rendus*: one by M. Forel, in the number of the 18th July, 1892 (p. 193), another by MM. Vallot and Delebecque on the 25th July, 1892 (p. 264), and the third by M. Demontzey on the 8th August, 1892 (p. 305). The last paper mentions the fact that some workmen saw the moving mass from a distance in the clear moonlight, and they gave five minutes as the time it occupied in passing from the gorge of St. Gervais to Le Fayet, a distance of 1800 metres, or at the rate of six metres a second. The writer also mentions the fact that the passage of the torrent has stripped the beds of the streams of Bionnassay and the Bon Nant of all the granite blocks which for long have been found there, and that the torrent when entering the Bon Nant at Bionnassay first drove right across the stream, and deposited materials of all sorts on the left bank at a considerable height.

Referring to what I said on p. 203, second column, as to the moving power of water, I think that it should be observed that the moving mass was by no means pure water, it was water, ice and mud, and I apprehend that the moving force of such a mass (which as a whole must be somewhat viscous) differs from that of pure water or any other true liquid.

Fig. 7 is so drawn as to represent the height of the water in the two communicating cavities as different. This is, of course, impossible, and I must ask my readers to make the necessary mental correction.

The following are the letters above referred to:—

From the Hon. Mr. JUSTICE WILLS.

The accumulation of such a mass of water at such a height is a very remarkable fact. I have once or twice seen cavities in the névé on a scale comparable with that on which the two holes in question were, but only once or twice. One was a very remarkable case indeed: on September 15th, 1858, I was descending the glacier d'Orny with a friend and two guides; we were still on the névé, and I noticed a thing which looked like a dark patch on the ice at a short distance from us. I said I should like to go and see what it was. As I drew nearer I saw it was a hole and I took the precaution of continuing in the rope, which we had not yet taken off. On reaching the spot, I went to the edge of the hole on my hands and knees and lay down to look into it. As soon as my eyes got accustomed to the comparative darkness into which I was gazing I saw to my horror that we were all of us on the crown of an arch of ice which from side to side was, if my recollection serves me, some 30 yards across, and which, at the top and at the very spot on which I was lying, was not more than a foot or 18 inches thick. The chasm extended in length further than I could see in either direction, but this was the only spot in which the top had given way. It was of great depth, I should think 100 to 150 feet, and there were many places in which pendants of ice, evidently formed by drip, were hanging from the roof; others in which blocks that had had ice pendants hanging from them had fallen into soft snow, or else merely got gently dislodged, for the ice pendants were still unbroken and yet pointing in many directions. It was a scene of really awful magnificence, and made a great impression upon all of us. We had walked across the arch without a suspicion of a hollow beneath, and yet the hollow was sufficient to engulf an army; we saw no water there.

I saw a thing of the same sort once on our own Buet, where the glacier is on so small a scale that we never dream of being roped. I saw a similar dark spot, went to look at it, found it was the top of an arched cavity on a very inferior scale to that on the glacier d'Orny, but still calculated to teach one respect and caution. I had a ball of string with me, and I tied my stick to the end of it and let it down what proved to be 84 feet before it touched bottom. Here, again, there was no water.

Melting at 9000 feet in height is a totally different thing to melting at 6000 or 7000 feet, and I have never seen a large crevasse in the névé charged with water, nor do I remember to have read of one. The highest of such that I ever remember to have had my attention called to, was on the upper plateau of the glacier des Bossons, perhaps 8000 feet or even more above the sea. We lost a little dog who fell down the crevasse by jumping short, and we heard him swimming quite out of sight. We let down a porter—fortunately we were a strong party and could pull him up again—and he found the dog on a ledge of ice at the edge of a deep pool. The dead weight of a big man to haul up again by main force was something I shall never forget. The crevasse twisted, and at one moment his broad shoulders got jammed and I thought we should not get him out again. But whatever height this was, it was far below the limits (at that place) of the névé, and the ice had none of the characteristics of the névé.

There is, however, very likely more drainage on the glacier des Têtes Rousses than on most glaciers of that height. I cannot say from personal recollection, as the only time I crossed a part of the glacier des Têtes Rousses, on an ascent of Mont Blanc by the Aiguille de Gouté, my attention was not drawn to the point, but I think it very likely that a part of the drainage from the Aiguille de Gouté may fall on to its side and get into its interstices. The Aiguille de Gouté is too steep for a permanent glacier to form on those ridges and furrows which are so great a characteristic of its structure. Vast quantities of snow fall and lodge upon these ridges and furrows, and melt very

rapidly in fine and hot weather, especially in the long days of June and July. It certainly needs some such contribution to account for so vast a store of water from mere drainage at that height. The surface snow of the névé is porous, and though a cake of ice often forms at night, it is sure to disappear with a few hours of sunshine, and to leave free access to soft snow beneath, and the surface meltings, which are never very great on the névé, filter into this, and do not run off as they do off hard ice—such as you meet with in your way up the Mer de Glace, for instance.

The circumstance of this vast accumulation of water in such a place is so very exceptional that a notion has been suggested (I forget where I have seen it—my son says it is in Freshfield's paper) that there are underground springs there. It would be very curious if this really were so. The distribution of underground water has always seemed to me a very interesting subject, and one which remains to be efficiently treated. That water travels very far under ground there can be no doubt I have seen in the Bay of Bengal, about forty miles north of Sumatra, a little island called Pulo Rondo. It is not two miles round, and rises about 250 feet out of the sea. A broad stream of water flows from its highest part down into the sea. In shape the island is like a barber's basin turned upside down, and there is no gathering ground, or none but the very smallest, above the top of the waterfall. That water must travel at least forty miles underground if the fall is brought about by hydrostatic pressure. But there are other collections of water which it is very difficult to account for by any such simple means. I know a small and very deep lake, about 1000 feet higher than the Lac Cornu (which is behind the Brévent from Chamonix), and nearly 9000 feet high, above which there is no gathering ground the least adequate to explain its existence, and I have always thought the Lac Cornu itself much larger than the area of which it receives the drainage can account for. In 1872 I noticed, during the N.W. monsoon and after a long period of dry weather, a small stream of water within a very short distance of the top of Pedro tallagalla, the highest mountain in Ceylon. I have reason to think that there is no great intrinsic improbability in the notion of a spring even at 9000 feet, and my son says that in Freshfield's article he mentions that De Saussure noticed a stream of *pure* water issuing from the base of the glacier des Têtes Rousses. It is a very rare thing indeed for the meltings of a glacier, which have passed any distance under the glacier, to be clear when they issue. You know what the Arve is at Chamonix in summer; I am told that in winter, when its volume is enormously diminished, it is *clear*, which may and probably does mean that it has a nucleus of spring water, which is what flows in winter.

But whatever the source of the sub-glacial accumulation, I think two things are clear: (1) That those large tanks, so to speak, are due to the motion of the glacier and not to the mere action of water. Water would, no doubt, do some little melting at the sides and on the floor of its receptacle, but in so confined a space the melting would be trivial; and as the water was accumulating and not changing, the action of melting ice round it would be to lower its temperature greatly. Such sheets of water as the Märjelen See hollow out great vaults underneath the ice. I once saw there a block of many hundreds of tons, on which it was the merest chance that four of us were not standing at the time, break off and fall into the lake, undermined. But then there is a lake nearly a mile long, above the freezing temperature, and with the surface warmed a good deal by the summer sun and the surface water between 32° and 39° sinking so as to keep the whole mass from getting down to the freezing point. In the cavities, in the present instance, the sun can have done nothing to warm the water after it got into them. (2) It is clear, I think, that the natural and usual drainage must have got blocked. As a rough general rule, where you have any very marked feature in glacial structure at any one time, you have it always. The séracs of the Col du Géant are constant. Particular passages over bergschrunds or through great mazes of crevasses, with a good deal of local variation, have yet a great amount of general constancy, and I suspect that whatever circumstances in the bed of the glacier, or what not, make a chasm, such as that in my glacier d'Orny, one year make it in a great many other years; and yet this accumulation is a new thing, or with the perpetual shifting of the ice which takes place in motion some such burst would almost certainly have taken place before. That there *was* a channel between the two cavities, I should have very little doubt, especially considering that the lower cavity is at a place where the incline of the glacier becomes much steeper than before. Generally speaking, no doubt, the cracks below the lower cavity give abundant outlet for the water, but some movement of the glacier must have blocked them up—a thing which one knows perfectly well does take place in numerous spots from time to time—and then the accumulation became formidable. The roof of either cavity was, in the course of glacier motion, bound to come down some day, and that it should break suddenly was to be expected. The ice avalanches that one has to look out for on the Petit Plateau, for instance, always happen without warning. That is to say, you see that the masses are getting dangerously near the edge of the cliff, but whether they will fall within five minutes or five days no human being can do anything more than guess. When the roof once did fall, being as it was very large the pressure on the containing system would be very great. In the instance I mention of the Märjelen See I was immensely struck with the commotion produced in the water, and yet there was an open lake a mile long with a long flat margin round a considerable part of it. It was half an hour before the recoil waves sent back from the end of the lake ceased to boom with ominous sounds against the ice cliffs, and the earlier recoils brought down fresh falls of ice. I am not the least surprised at the dam at the end being burst, and at the rush of water from above sweeping the lower hole pretty clear of water.

An illustration of the fact that drainage through the lower strata of a glacier sometimes gets blocked for long periods together occurs to me. When I first knew the Mer de Glace well, in 1857, there was, at the foot of the Tacul, in the angle between the glacier du Géant and the glacier de l'Echaud, a large lake certainly more than a quarter of a mile long. I have visited the same spot in fourteen different years since. I have never seen it so large again, and many years it has not existed at all. The difference is chiefly due to drainage.

I think your paper on the St. Gervais disaster, as far as I can judge from what has so far been ascertained, is quite right as to the *modus operandi*. If all be well, I hope to go and see the course of the torrent next autumn, and it is fairly certain that one year will make very little difference in the physical appearances. It is the second time I have known the broader valley below St. Gervais covered with *débris*. In 1852 there was a wonderful fall of *warm* rain over the whole range of mountains for nearly three days. I got to Chamonix on the third of these days, having come down the Great St. Bernard and through Martigny, and having met with floods which gave us some very long détours to make. Parts of the valley of Chamonix, but very much more the embouchure of the stream which comes from the Col du Bonhomme and receives all the lateral drainage from the Mont Blanc chain, were covered at least three or four feet deep with *débris* and glacier mud. Now, I fancy, the depth of deposit is nearly ten times what it was then. I am sure what I saw then was terrible enough. In one place we saw the actual birth of a torrent of mud, saw it burst out of the mountain side and spread over the cultivated patches above the hamlet of Le Tour.

From CHARLES TOMLINSON Esq., F.R.S., &c.

It may be thought presumptuous in me to form any opinion on the subject, seeing that I have not visited the spot, nor studied the phenomena *in situ* as you have done.

But I venture to remark that I miss from the account any reference to the hydrostatic force of water, which is sufficient of itself to do any amount of mechanical work without subsidiary aid of any kind.

A cubic foot of water weighs upwards of 62 pounds, and in consequence of the perfect distribution of fluid pressure in all directions the pressure on a square foot of water at the depth of ten feet is upwards of 623 pounds.

But the cavity containing the pent-up water which caused the disaster is estimated at a vertical depth of 130 or 160 feet, which gives a pressure on the lowest foot of water of 8060 and 9920 pounds, which pressure is repeated on every cubic foot along the lowest line but diminishes upwards to the surface cubic foot pressure of 62 pounds. Hence, we have a force acting day and night all the year round, which in time must break through any icy barrier that is likely to be opposed to it. The fall of ice from the roof could not act as a piston or lend any efficient aid to the result. There are also objections to the word "suction." My conclusion (subject to the objections noted at starting) is that hydrostatic pressure alone was the only moving originating cause of the calamity.

There are, however, a few other considerations which I take the liberty of adding to this proof which the Editor has been so good as to forward to me.

The warm weather that preceded the catastrophe would tend to fill up the sub-glacial reservoirs, and also to thin the outer wall of ice. If an opening had been made at the base of the deeper or 160 feet cavity (the velocity of the outflow being as the square root of the depth) the rush of water would have been thirteen times greater than at the top. But I imagine there was no point or line of least resistance at or near the base of the cavity but was spread over its whole surface, so that as the water accumulated, a moment arrived when the resistance was not equal to the pressure, and the whole exposed face of the icy barrier was burst open at once, and the contents of the reservoir, thus set free, proceeded rapidly on the work of destruction.

A VOLATILE SERIES OF METALLIC COMPOUNDS.

By C. F. TOWNSEND, F.C.S.

THE progress of chemical science is continually bringing to light new wonders and startling paradoxes. Nothing more remarkable and unexpected has occurred in the recent history of chemistry than the discovery of the compounds of nickel and iron with the gas generally known as carbon monoxide or carbonic oxide. The new compounds are called respectively nickel and iron carbonyls, and have evidently a great future before them. Judging from chemical precedent, one would quite as soon have expected oil and vinegar to form a homogeneous mixture as a combination of the bodies referred to. In fact, so anomalous did it appear when Mr. Ludwig Mond first brought the accidentally discovered nickel compound to the notice of the Chemical Society in the middle of 1890, that many almost refused to believe in the possibility of its existence. However, there is no doubt about it. Nickel carbonyl, a considerable quantity of which was exhibited at a *conversazione* of the Royal Society held in June last, and also at the meeting of the British Association, is obtained by merely passing carbon monoxide—a product of the incomplete combustion of coke or charcoal, and which may often be seen burning with a lambent blue flame at the top of a clear fire—over the finely divided metal, and condensing the resulting vapour in a tube surrounded with ice and salt. Its properties have been very fully investigated both by its discoverers, Messrs. Mond, Langer, and Quincke, and also by M. Berthelot, who published his results in the *Comptes Rendus*.

It is a liquid of very high refractive power and brilliant appearance, and considerably heavier than water, under which it may be kept without change, provided the vessel is completely filled and the water contains no air. It solidifies at 13° F., and boils at 109° F., and the vapour, if lighted, burns with a strongly luminous flame, which appears smoky in consequence of the separation of metallic nickel. The liquid is very volatile, and if the vapour is suddenly heated a sharp detonation is caused. A mixture of nickel carbonyl with air takes fire if brought into contact with a very hot body, and occasionally explodes. A mixture of the dry vapour and oxygen may be detonated by simple agitation over mercury, and strong oil of vitriol produces the same effect in a few minutes. The vapour, when heated to 358° F., splits up again into its original constituents, the metal and the gas, and the nickel deposits itself as a brilliant coating on the sides of the vessel. Advantage is taken of this circumstance to apply the carbonyl to nickel-plating, and a patent has been taken out by its discoverers for working it on a commercial scale. At the last meeting of the British Association, Mr. Ludwig Mond described the various uses to which the discovery might be put, and the possibilities which it opened up. The nickel-plating can be accomplished by simply exposing the goods, after being heated to the temperature just mentioned, to nickel carbonyl vapour, and solid articles can be similarly formed by passing the vapour through heated moulds. For this purpose, it is found advantageous to dilute the vapour considerably with air. Nickel can also be deposited on any substance by treating it with the liquid itself, or better, by nickel carbonyl dissolved in suitable solvents. These processes possess a great advantage over electro-plating, as not only metal, but any substance, however intricate in design or fragile in structure, can be coated with a brilliant film of nickel by its means without the tedium and risk of first covering it with a surface of blacklead. Some very beautiful specimens of real flowers, plated with different metals, principally gold and silver, so as to bring out the various parts of their structure, were exposed for sale at the Frankfort Electrical Exhibition. A syringa blossom, for instance, would have its stamen and anthers plated with gold, its corolla with silver, and the stalk and calyx with copper. Needless to say, they found a ready market. The field before this new process is practically unlimited, for not only could it be applied to ornaments and articles of household use, but, if required, to delicate muslins, and dress or other fabrics.

The liquid nickel carbonyl is highly poisonous, and, if injected subcutaneously, acts very powerfully on the animal system, producing an immediate and remarkably prolonged fall of temperature. It might, perhaps, be introduced into medical practice as an antipyretic in the treatment of fevers, were it not for the difficulty of administering it in sufficiently small doses, and its intensely poisonous action. The carbon monoxide alone is the active agent in causing this effect, the symptoms being those of respiratory poisoning; and the blood of animals killed by it exhibits the same appearances as that of persons suffocated by inhaling the fumes of burning charcoal. This kind of poisoning is particularly dangerous, and in cases of recovery the effects do not wear off for several hours after. The red corpuscles of the blood owe their colour to a complex chemical substance known as hæmoglobin, which acts as the carrier of oxygen. In passing through the lungs oxygen is taken up, and it is converted into oxy-hæmoglobin, which, when placed so as to intercept the rays of light in the spectroscope, gives quite different absorption bands to the hæmoglobin itself; from the lungs the oxygen is carried to different parts of the body to be exchanged for carbonic acid, which is brought back to be eliminated and again replaced by oxygen, thus completing the cycle. Carbonic oxide combines with the hæmoglobin to form carboxy-hæmoglobin, an exceedingly stable substance which can only be displaced by oxygen with the greatest difficulty. The consequence is that the blood is unable to perform its functions, and the animal rapidly dies from suffocation. The absorption spectrum of this last body is remarkably characteristic and quite unmistakable, forming an infallible test in case of suspected poisoning by charcoal fumes. The vapour of nickel carbonyl is as deadly as the liquid, and is dangerous in air even to the extent of only 0·5 per cent.

The extraction of the metal from its ores is another valuable use to which the discovery of this compound will almost certainly be put. The principal sources of nickel are the copper-coloured arsenical mineral which the German miners—after working it unsuccessfully for years in the hope of obtaining copper—called *kupfer-nickel* (*i.e.*, false copper), and in which the metal was first discovered by Cronstadt in 1751, and *speiss*, an impure residue formed at the bottom of the melting-pots in the manufacture of the bright blue pigment known as *smalt*, which is largely used by paper-stainers. Metallic nickel is obtained from these by heating them with charcoal in a furnace, but the product only contains about 60 per cent. of the pure metal. It appears now that it will be sufficient to pass carbon monoxide over the crushed mineral, and by simply heating the resulting nickel carbonyl to 358° F. chemically pure nickel will be deposited.

All attempts to obtain a similar compound with other metals for a long time proved unsuccessful. As it seemed improbable that nickel should be the only metal forming such a compound, the investigators persevered with the

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work, and finally succeeded in volatilizing distinct quantities of iron in a current of carbon monoxide. The issuing gas burned with a yellowish flame, and if passed through a heated tube deposited a metallic mirror in the glass, which answered to all the tests for iron with unusual brilliancy. The quantity produced was, however, very small, and the process exceedingly laborious, for it took no less than six weeks to volatilize about thirty grains of iron. Even under the most favourable conditions the gas never contained more than 0·2 per cent. of the compound, but by varying the details of the process a much larger yield was obtained.

The iron carbonyl thus produced is a pale yellow viscous liquid, nearly half as heavy again as water. It distils without decomposition at 220° F., and solidifies below 6° F. into yellowish needle-shaped crystals. It decomposes slowly on exposure to air and, like the nickel compound, is completely broken up by heating its vapour to 356° F. On the other hand, it is much less active than its analogue and is not attacked by dilute oil of vitriol. Its composition was at first thought to be similar to that of nickel carbonyl, but on accurate analysis it was found to contain five proportions of carbon monoxide [$Fe(CO)_5$] instead of the four which constitute the latter [$Ni(CO)_4$].

Whilst engaged in some experiments on the utilization of water-gas (which is manufactured by passing steam over red-hot coke, and contains about 40 per cent. of carbonic oxide) for illuminating purposes by means of the Farnehjelm system, in which a comb of magnesia is raised to incandescence by a number of fine gas jets, Sir H. E. Roscoe and Mr. Scudder noticed that a red deposit of oxide of iron was formed on the rods after the water-gas had impinged on them for a few hours. This was a very serious drawback, as the illuminating power became considerably reduced. As the experiments were being conducted in a steel works the first supposition naturally was that the stain was caused by fine particles of iron present in the atmosphere, but closer inspection showed that the deposit was of a "coralloid" structure and must, therefore, have been produced by the gas itself. In order to ascertain whether the iron existed in the gaseous state or was carried forward chemically, the gas was filtered through several tight plugs of cotton wool. No difference, whatever, was observed and it was concluded that the gas contained a very minute quantity of a volatile compound of iron. Shortly after it was subjected to various chemical tests, which left very little doubt as to its identity with iron carbonyl.

Coal gas has also been found to contain iron, derived, no doubt, from the slow action of the 7 or 8 % of carbon monoxide it contains on the iron of the mains and gas pipes. This accounts for the hitherto unexplained black stain so frequently observed on steatite and other burners. Compressed coal gas has begun to take the place of hydrogen in the production of lime-light, and the stain formed on the lime cylinders is very noticeable, being, it is almost needless to say, somewhat of a drawback to its use.

The discovery of this series of compounds is quite a revelation to the metallurgical chemist, and already explains many mysteries. In the cementation process for the manufacture of steel, bars of iron are embedded in powdered charcoal, and kept at about the melting point of copper (2192° F.) for eight or ten days. Steel, as is well known, is an alloy of iron, with a combination of carbon and iron, called carbide of iron, and the principle of all steel-making is the same: carbon must be added to soft iron in definite proportions. If the iron contains no carbon it is comparatively soft and malleable. Wrought iron contains less than 0·3 % of carbon; steel from 0·3 to 1·5 %: above this the metal takes the character of cast-iron. The charcoal which surrounds the bars of iron in the process just referred to, occludes a large quantity of air in its pores, which, when heated, forms carbonic oxide. This gas permeates the iron and gives up its carbon to the metal, returning again to take up a fresh supply from the charcoal, and thus acts as a carrier of carbon to and fro in the interstices of the iron, which it gradually converts into almost homogeneous steel, known technically as *blister-steel*, owing to its peculiar vesicular appearance caused by the penetration of the gas. These compounds must play a very important part too in the blast furnace, and in both the Siemens and the Bessemer process, especially the latter. Bessemer steel is made from cast-iron; the carbon and impurities are burnt out of it by driving a current of air through the molten metal. When this has been accomplished, a highly carburetted cast-iron, called *spiegeleisen*, is thrown into the converter in properly regulated quantity, and the carburation of the iron is rapidly effected.

Renewed attention has recently been directed to some volatile compounds of platinum with chlorine and carbon monoxide, which are broken up by water with deposition of pure platinum, thus forming a possible way of extracting the metal from its ores. If any discovery of this kind were to facilitate the extraction of gold, which at its present rate can barely keep up with the demands of the increasing consumption, an immense boon would be conferred on the civilized world.

CATERPILLARS.—III.

By E. A. BUTLER.

(*Continued from page* 229, *Vol.* XV.)

IN some caterpillars the usual complement of ten prolegs is greatly reduced, only the last two pairs being present; thus all the six central segments of the body are left without means of support. This, of course, necessitates a special method of progression, the wave-like motion already described being clearly impossible. Caterpillars of this kind take a firm hold alternately with the two ends of the body, the central part being by turns arched up and extended, as the animal advances, not with the creeping motion of small paces, but with the stately gait of long strides. Thus, when the insect is in a fully extended position and wishes to advance, it clings tightly with its six true legs, and then, releasing its claspers and lifting the hinder part of the body, hooks them on again close up to the legs, thereby causing the intervening portion of the body to assume the form of a perpendicular loop; then, holding tightly by the claspers, it lifts the legs and advances the front part to the fullest extent, straightening out the loop and bringing itself again into its former horizontal position. From their peculiar mode of walking, by curves and loops, caterpillars of this kind are called geometers or loopers. They are always long, narrow, thin-bodied creatures, usually green or brown in colour, and often with the head divided on the crown into two prominences like faint indications of horns. They are noted for the extraordinary positions they assume, and the remarkable way in which they mimic little twigs or stems. When at rest, the body is usually kept straight and stiff at an acute angle to the twig, inclined to about the same extent as the twigs themselves are to the main stem, the mechanical difficulties of such a position being met to some extent by an exceedingly fine thread of silk stretching from the spinneret to the twig, or less frequently by the anterior legs clasping another twig in the neighbourhood. The silken thread provides means of

suspension in the air if a sudden displacement of the claspers should take place, and sometimes prevents a fall to the earth, and saves the consequent labour of getting over uneven ground to reach the tree trunk and then climbing, perhaps, many feet of rough bark before the former position can be regained, and at the same time it forms a considerable security against the fatal results which might follow from striking against intervening branches while falling with gradually increasing velocity.

The general resemblance to a small twig, caused by the cylindrical shape and the brownish colour, is often heightened by the presence on the back of excrescences of various kinds, similar to what may be seen on the twigs of the food-plant. A very abundant insect, the caterpillar of the brimstone moth (*Rumia crataegata*), a pretty sulphur-coloured moth with a few reddish patches and streaks, and a common inhabitant of gardens in summer-time, may be taken as an excellent exemplification of this. It is tinted with almost exactly the same mixture of purplish and reddish brown as the twigs of its commonest food-plant, hawthorn; its thickness is about that of the young twigs amongst which it lives, and halfway down its back it bears a wart-like excrescence which very closely resembles the knotty little protuberances seen in similar positions on short stumpy twigs of hawthorn. This same insect exhibits also another very beautiful arrangement whereby the resemblance to a twig is rendered still more perfect. When the two pairs of claspers are in position grasping a twig, it is evident that, if that part of the body which lies between them were of the usual shape, evenly cylindrical in outline, there would be a space between its under surface and the twig, which would be thrown into shadow, and the presence of this clearly-defined dark line of shadow just where the pretended twig ought to pass uninterruptedly into the parent stem would be a flaw which would detract from the perfection of the mimicry. Hence we find that the skin between these two pairs of claspers runs out into numerous little irregularities, forming flaps which reach to the twig itself, and therefore break up the shadow and soften the contact with the stem. If this irregularity of outline were found all along the body, it would hardly be safe to lay much stress upon its presence between the hind legs; but this is not the case. The fringe occurs only where the body comes into contact with the twig, and its presence just where it is needed, and its absence elsewhere, lend probability to the above explanation of its function.

A thoughtful consideration of cases such as this will serve to show what an endless field of investigation is opened up, when even the knobs and humps and excrescences of caterpillars are found to be not the mere meaningless freaks of some sportive and erratic force, as they at first appear, but exquisite adaptations whereby the organism has been brought more completely into harmony with its environment; adaptations, therefore, which have some bearing either upon its preservation amidst its present conditions of life, or upon its past history and the course of events which have constituted its life as a species.

In this latter connection we may refer to the caudal horns of the caterpillars of the hawk moths (*Sphingidæ*). These insects have on the back of the last segment but one a curved horn, which contributes in no slight degree to the air of stateliness that characterizes them when they assume the sphinx attitude. The horn usually points more or less upward, and shows only a single curve, but in some cases, as in the death's head moth (*Acherontia Atropos*), it is depressed, and doubly curved into an S-shape. When a hawk moth caterpillar is first hatched, the horn is much longer, proportionately to the body, than when fully grown; it is also straight, almost erect, and forked at the tip (Fig. 7), and its surface is beset with prickles. As the insect grows, the prickly tubercles on the horn become, in some species, less conspicuous, and finally entirely disappear, the horn becoming smooth and polished; in others they are retained throughout life.

FIG. 7.—Caudal horn of Convolvulus Moth Caterpillar, at different stages. A, B, C, magnified 5·8, 3, and 2 diameters; D, natural size. The magnification is not sufficient to show the tubercles. (From Poulton.)

The forked appearance of the tip disappears after the second moult, and the horn curves more and more downwards. Not only is the horn of the newly-hatched larva thorny, but the whole surface of the body is covered with minute tubercles, each of which emits a small hair. In some species, such as the poplar and eyed hawk moths, these tubercles are retained throughout life, giving rise to that roughness of skin which is described as shagreening. In other cases, such as the privet hawk moth, they are lost after the early stages, and the skin becomes quite smooth. In this family of moths, then—a family which consists of insects whose general resemblance testifies to their real relationship—we see caterpillars that commence life with well-marked characters, which they afterwards lose to a greater or less extent. Such characters do not seem to bear any special relation to their present surroundings, and may therefore be fairly regarded as common ancestral relics, implying that the insects are descended from progenitors with forked and tuberculated horns. Some of the species, however, have advanced farther from this ancestral condition than others.

There is another family of large and handsome moths, very different in shape, style, and habits from the hawk moths, but nevertheless exhibiting some curious resemblances to them in the caterpillar condition. This is the family *Saturnidæ*, or emperor and silk-producing moths, distinguished by the coloured or transparent, circular or crescent-shaped eye-spots in the centre of the wings. The family is very poorly represented in Great Britain, only two species, the Kentish glory and the emperor moth, being native with us. The former of these is in some respects very unlike its associates, and the caterpillar is quite distinct; but the emperor moth (*Saturnia carpini*) may be regarded as a good illustrative type of the group. The caterpillars of this family are generally large and fleshy creatures, adorned with rows of rounded tubercles from which spinous hairs project. Our British species is a bright green insect with a row of pink tubercles on each segment. In some species there are not only the usual tubercles, but various spines or hornlike projections as well in different parts of the body. These show a tendency to be developed about the thoracic and caudal regions. In some cases the spines are single-pointed, but in others forked and tuberculated. Moreover, when the spines are large, the tubercles on the rest of the body are small, as though the spines were enormously-developed tubercles, which, by reason of their superior protective powers, could afford to dispense with their smaller and weaker brethren.

But the most remarkable facts of all are to be found in connection with the caterpillar of the Tau emperor (*Aglia tau*), a species about $2\frac{1}{2}$ inches in expanse of wings, and so

named from the white T-shaped mark contained in the blue "eyes" on its wings. This fine insect is found in several parts of the world, including some European countries, though not in Britain. The newly-hatched caterpillar is green with five red-forked and tuberculated horns (Fig. 8), two pointing straight forward above the head,

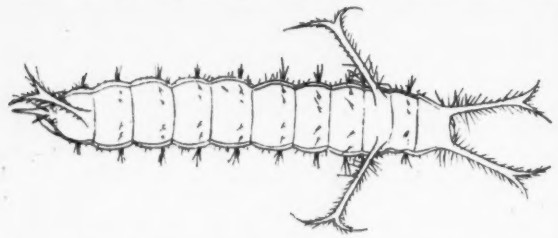


FIG. 8.—Young larva of Tau Emperor Moth, magnified 7 diameters. (After Poulton.)

two projecting from the sides of the thorax, and one pointing upward and backwards from the dorsal surface of the last segment but one, just the position of the caudal horn of the *Sphingidæ*. The hair-bearing tubercles on the rest of the body are also present, but small. This remarkable appearance is retained by the caterpillar during its first three stages, but at the next moult the whole of the apparatus of spines and tubercles suddenly and entirely disappears, the only trace of the former condition being a general shagreening of the body similar to that of some of the hawk moths. There are now also other resemblances to the *Sphingidæ*, such as the assumption of the sphinx attitude, and the presence of oblique coloured stripes on the sides. Facts such as these, pointing as they do to a kinship between the two great families of hawk moths and emperor moths, evidently impart a new interest to the caudal horn of the former, and suggest that it may be the solitary and modified remnant of a complete ancestral armature, a monument of bygone times, and a key to the past history of the race.

A curious point is suggested in connection with these horns, viz., as to the accommodation within the oval eggshell for caterpillars of shapes so awkward for packing up into a small compass. The problem is not in all cases solved in the same way. Before hatching, the horn of the *Sphingidæ* is flexible, and is bent round along the sides of the eggshell; but a different method of stowage is adopted in the case of *Aglia tau*. Here there are five horns instead of one to be packed away, and they would evidently get rather in the way if dealt with in the same manner. Accordingly, it is found that they are not of full size in the egg, but appear as small curled tubercles, which expand to the full form and size *after* hatching, by the passage into them of blood from the body, in much the same way as the wings of a Lepidopterous insect are expanded after it has left the chrysalis.

From horns, tubercles, spines and tails the transition is not difficult to hairs—in fact it is not easy to say where spines cease and hairs begin; the structures are similar in plan, and differ chiefly in diameter and in the degree of flexibility or stiffness that results therefrom. Hairs and spines may be either simple or branched. Good examples of branched spines may be seen in the caterpillars of many butterflies, such as the tortoise-shells, peacock, red admiral, painted lady, and fritillaries. Densely hairy larvæ are specially characteristic of the group of moths called Bombyces (tigers, ermines, eggers, &c.). The common "woolly bear," or caterpillar of the garden tiger moth (*Arctia Caja*), may be taken as the most familiar example. The hairs here emanate from small white tubercles placed on a velvety black body; in front and at the sides they are rust-coloured, but on the rest of the body black tipped with white. To the naked eye they seem to be simple, but the microscope easily shows them to be finely feathered (Fig. 9), with minute branches placed at considerable intervals alternately along the main stem. Their length is so great that their effect is to more than treble the insect's apparent diameter; they are, moreover, pre-eminently elastic and recoil powerfully when bent. When disturbed, the caterpillar rolls itself into a ring, and the hairs, then radiating in all directions, make it a most difficult object to handle, their elasticity causing it to elude the grasp again and again, so that it is impossible to seize it firmly. Obviously, therefore, they are a valuable means of protection. The habit of rolling into a ring is closely connected with the hairiness of the larva, the one fact indeed being the complement of the other; as with the hedgehog, the only vulnerable parts are by this means protected, and it is easy to see that a smooth caterpillar would gain little by the device. Hence we find that the habit of rolling into a ring is very prevalent amongst densely hairy caterpillars, though not universal; moreover, it is a habit not entirely confined to such larvæ, though much commoner amongst them than in other groups. It is often said that hairy caterpillars are avoided by birds; but this again is not universally true. That extremely shaggy creature, the larva of the fox moth (*Lasiocampa rubi*), than which it is scarcely possible to imagine anything hairier, might, one would suppose, be a sufficiently disagreeable mouthful; yet the Rev. Harpur Crewe speaks of a bee-eater, which one autumn visited the Scilly Islands, as having lived principally upon these larvæ; it seized them with its beak, and then, beating them on the ground till they were dead, swallowed them whole.

FIG. 9.—Hairs of Caterpillar of Tiger Moth, much magnified.

The distribution of the hairs varies very much in different species. When they are fine and collected in closely-compacted tufts along the back, like a row of shaving brushes cut off flat at the top, they form what are called "tussocks" (Fig. 10). The most beautiful example of this is the caterpillar of the pale tussock moth (*Dasychira pudibunda*), an insect of a very pale and delicate green colour, with velvety black crescentic bands at the junctions of the central segments. These black patches are not seen under ordinary circumstances, being concealed by the overlapping of the segments, but they are suddenly revealed when the insect bends its head under in its terrifying attitude, and more distinctly still when it adopts its final refuge and rolls into a ring. On the back are four large dense tussocks of a bright yellow colour, in startling contrast to the black bands between them, which by the effect of irradiation make them look more conspicuous and larger than they really are; at the hinder end, in the position of a caudal horn, is a sort of tail consisting of a brush of rose-coloured hairs. This lovely caterpillar, one of the most exquisite of British species in the delicacy and purity of its tints, is common in most places, and may be found in the summer feeding on a variety of trees; to the country folk it is known as the "hop-dog." The hairs of

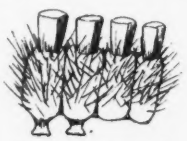


FIG. 10.—Central segments of body of Caterpillar with tussocks.

the tussocks very easily come out, though the tussocks themselves look solid and unyielding, and seem to be the most appropriate parts for an enemy to seize upon; but if they be roughly seized, their silkiness causes them to slide from the grasp, the caterpillar thus escaping and leaving with its would-be captor a little bundle of tickling hairs as the only trophy. Mr. Poulton has pointed out that the tussocks may in this way be of some protective value. He offered a "hop-dog" to a hungry green lizard. The animal was apparently experienced enough to know the deceptiveness of the tussocks, but, nevertheless, the promptings of hunger were imperative and it resolved to make a venture, but it carefully avoided the tempting tufts and kept trying for some minutes to find a more suitable point for attack; it finally seized the caterpillar on the back some distance behind the tussocks, whence the moral seems to be that a less hungry assailant would probably have left the hairy morsel alone. A somewhat similar caterpillar, that of the vapourer moth (*Orgyia antiqua*), on being offered to another and, as it proved, less cautious lizard, was at once seized by the tussocks, but its assailant had the mortification of losing its prey, and getting only a mouthful of hairs for its pains; these were by no means to its taste, and it thus learnt a lesson of prudence by the experiment, and made no attempt to mend its fortune by any other venture in the same direction.

(*To be continued.*)

THE NUMBER AND DISTANCE OF THE VISIBLE STARS.

By J. E. GORE, F.R.A.S.

THAT the visible stars are not uniformly scattered through space, and are not of uniform size and intrinsic brightness, is clearly shown by modern researches. Measures of stellar parallax show that some small stars (that is, faint stars) are actually nearer to our system than many of the brighter stars, while the period of revolution of some binary stars shows that their mass is relatively small compared with the brilliancy of their luminous surfaces. We may, however, perhaps assume that the stars out to some limited distance in space are scattered with some rough approach to uniformity. We can at least calculate the average distance between the neighbouring stars, which would give a certain number of stars in a sphere of given radius. This is easily done by supposing the stars placed at the angular points of a tetrahedron. A tetrahedron is a solid figure bounded by four equal surfaces, each surface being an equilateral triangle. It is clear that in such a solid each of the angular points is equidistant from the other three angular points of the figure.

If e be the length of the side of each equilateral triangle (or edge of the tetrahedron) it may be easily shown, that the volume of the tetrahedron is $\frac{1}{12} e^3 \sqrt{2}$. If we make $e=1$ the volume is $\frac{1}{12}\sqrt{2}$. Now it is clear that the number of equidistant points contained in a sphere of given radius will be equal to the number of these tetrahedrons which the sphere contains. If r be the radius of a sphere, its volume will be $\frac{4}{3}\pi r^3$, and if n be the number of equidistant points or stars contained in the sphere, we have $\frac{4}{3}\pi r^3 = n \times \frac{1}{12}\sqrt{2}$, whence $r = \sqrt[3]{\frac{n}{35{\cdot}548}}$, and $n = r^3 \times 35{\cdot}548$. From these formulæ we can compute the radius of a sphere containing a given number of equidistant stars, or the number of stars contained in a sphere of given radius.

This formula, however, only applies to a sphere of a radius large in comparison with the distance between the stars distributed through it. For if we make $e=r=1$, or the distance between the stars equal to the radius of the sphere, the formula would give 35 equidistant stars in the sphere of unit radius. This number is evidently too great, as the number of stars which can be placed on the surface of a sphere of given radius, equidistant from each other and from the centre of the sphere, is only 12. The difference is clearly due to the fact that in this case the volume of the tetrahedron is so large in proportion to the volume of the sphere that the latter cannot be accurately divided into tetrahedrons. In the case, however, of a sphere whose volume is large in proportion to the volume of the tetrahedron formed by four adjacent stars, the formula will be approximately correct. Let us call the distance between two adjacent stars the *unit distance*.

Now considering α Centauri, for which the largest parallax has been found (about 0·76″), it is obvious at once that this star cannot be at the "unit distance" from the sun. For if α Centauri was at the "unit distance" we might expect to find some ten or eleven other stars with a similar large parallax. Such is, however, probably not the case, and we may therefore conclude that this star is comparatively near our system, and forms an exception to the general rule of stellar distance.

To make this point clearer, let us see what number of stars should be visible to the naked eye—say to the sixth magnitude inclusive—on the assumption that the distance between the sun and α Centauri forms the "unit distance" between two stars of the visible sidereal system, or at least that portion of the system which is visible without a telescope. To make this calculation it will of course be necessary to assume some average distance for stars of the sixth magnitude, based on actual measurement. Now Peters found an average parallax of 0·102″ for stars of the first magnitude, Gyldén found 0·083″, and Elkin 0·089″. These results are fairly accordant, and we may assume the mean of these values, or 0·09″ as the mean parallax of an average star of the first magnitude.

With a "light ratio" of 2·512, the light of a first magnitude star is 100 times the light of a sixth, and hence the distance of an average sixth magnitude star would be ten times that of a first. Its parallax would therefore be 0·009.″ Hence the radius of a sphere containing all stars to the sixth magnitude inclusive would be $\frac{0{\cdot}76}{0{\cdot}009}$ or 84·4 times the distance of α Centauri. Hence we have $n=(84{\cdot}4)^3 \times 35{\cdot}548 = 21{,}372{,}000$, a number enormously greater than the known number of stars to the sixth magnitude.

This leads us to doubt whether the mean parallax of sixth magnitude stars is so small as 0·009″. I find that the sun placed at the distance indicated by this parallax would shine only as a star of the eleventh magnitude; that is, a sixth magnitude star would be five magnitudes, or 100 times brighter than the sun placed in the same position. If of the same intrinsic brilliancy of surface, this would imply that an average sixth magnitude star has ten times the diameter of the sun, and therefore 1000 times its volume! Some sixth magnitude stars may possibly exceed our sun in size, but that the *average* volume of these small stars is 1000 times that of the sun seems wholly improbable. Certainly the calculated masses of those binary stars for which a parallax has been determined do not give any grounds for supposing that such enormous bodies exist among stars of the sixth magnitude.

Assuming, however, that the parallax of a first magnitude star is 0·09″, and that of a sixth magnitude is one-tenth of this, or 0·009″, let us see what number of stars should be visible to the sixth magnitude. As already stated, the number of equidistant stars which can be placed on the

surface of a sphere of unit radius is 12. Hence, on the surface of a sphere of double this radius, four times the number, or 48 equidistant stars may be placed; on a sphere of three times the radius, nine times the number, and so on. Now the sum of ten terms of this series 1^2, 2^2, 3^2, etc., is 385, and as the twelve stars which may be placed on the first sphere nearly represent the number of stars of the first magnitude and brighter visible in both hemispheres, we have the total number of stars to the sixth magnitude inclusive, $385 \times 12 = 4620$.

Now the number of stars to the sixth magnitude in both hemispheres as observed by Heis and Gould, is 4181, and the number contained in the "Harvard Photometry" and the *Uranometria Argentina* is 3735, so that the number of stars computed on the above principle does not differ widely from the number actually observed.

Let us see, however, what the unit parallax would be for the observed number of stars to the sixth magnitude, assuming a parallax of 0·009″ for stars of this magnitude. Taking the number as 3735, we have by the tetrahedron formula $r = \sqrt{\frac{3735}{35 \cdot 548}} = 4 \cdot 7187$ times the average distance between the stars, and since $r = \frac{\text{parallax}}{0 \cdot 009}$, we have the "unit parallax" $= r \times 0 \cdot 009'' = 4 \cdot 7187 \times 0 \cdot 009 = 0 \cdot 042468$; that is, the mean parallax of the nearest stars to the earth would be 0·042″. Excluding stars with a large parallax, this may not perhaps be far from the truth. I find that in 31 binary stars brighter than the sixth magnitude (and for which a parallax has not yet been determined), the average "hypothetical parallax"—or the parallax on the assumption that the mass of the system is equal to the mass of the sun—is 0·068″. If we assume the mass of each of these systems to be, on an average, twice the sun's mass, we must divide this by the cube root of 2. This gives for the average parallax 0·054″, which does not differ widely from the unit parallax found above for stars of the sixth magnitude.

But we are still confronted with the difficulty that with a parallax of only 0·009″, stars of the sixth magnitude would be on the average considerably larger than the sun. The same remark applies to stars of the sixteenth magnitude, for which the parallax would be (with the light ratio of 2·512) only 0·00009″. Placed at this vast distance the sun would, I find, be reduced to a star of magnitude 21·3, and would, therefore, be utterly invisible in the largest telescopes yet constructed. It would be over 100 times fainter than a star of the sixteenth magnitude!

To reduce the sun to a star of the sixth magnitude, it should be placed at a distance corresponding to a parallax of 0·1″. Unless, therefore, stars of the sixth magnitude are, on the average, considerably larger than our sun, we seem justified in thinking that their average parallax is not less than one-tenth of a second. But, as has been stated, this is about the average parallax of stars of the first magnitude, and it is difficult to believe that these bright stars are as far from the earth as the comparatively faint stars which lie near the limit of naked eye vision. There seems, however, no escape from the conclusion that sixth magnitude stars are probably nearer to us than their brightness might lead us to suppose, and to explain the difficulty with reference to the bright stars, we may perhaps assume that their brilliancy is due rather to their great size than proximity to our system. From the small parallax found for Arcturus, Vega, Capella, Canopus and other bright stars, we have good reason to think that these stars are vastly larger than our sun. Spectroscopic observations of ζ Ursæ Majoris indicate that this second magnitude star has a mass about forty times the mass of the sun, and possibly other bright stars may have similarly large masses. Sirius and α Centauri, however, form notable exceptions to this rule.

Assuming an average parallax of 0·1″ for stars of the sixth magnitude, the parallax of a star at the "unit distance" from the sun would—on the tetrahedron formula—be 0·47″. This is about the parallax found for 61 Cygni, and does not much exceed that of Sirius. There are several other stars with a parallax of somewhat similar amount, and possibly there may be others hitherto undetected.

With a parallax of 0·1″ for a sixth magnitude star, the parallax of an eleventh magnitude would be 0·01″, and that of a sixteenth magnitude 0·001″. Now, with the unit distance corresponding to a parallax of 0·47″, let us see what would be the number of equidistant stars contained in a sphere of radius equal to the distance of a sixteenth magnitude star. We have $r = \frac{0 \cdot 47}{0 \cdot 001}$, or 470 times the distance between the adjacent stars. Hence $n = (470)^3 \times 35 \cdot 548 = 3{,}690{,}700{,}000$, a number about 36 times greater than the number of the visible stars, generally assumed at 100 millions. According to Dr. Gould's formula (sum of stars to m^{th} magnitude inclusive $= 1 \cdot 0051 \times (3 \cdot 9120)^m$), the number of stars to the sixteenth magnitude would be 3,024,057,632, or about 30 times the number actually visible.

Probably, however, we are not justified in assuming a uniform distribution of stars to the sixteenth magnitude, most of these faint stars belonging to the Milky Way. Professor Celoria found that, near the pole of the Galaxy, a small telescope which showed stars to only the eleventh magnitude revealed as many stars as Herschel's gauging telescope of 18·8 inches aperture. Here, therefore, we seem to have the extension of our sidereal system limited to the distance of eleventh magnitude stars. Let us now assume a uniform distribution of stars to the eleventh magnitude. With a parallax of 0·01″, and a "unit parallax" of 0·47″, we have $r = (47)^3 \times 35 \cdot 548 = 3{,}690{,}700$. The number by Gould's formula is 3,283,876. Both results are largely in excess of the number actually visible, and show, I think, that there is probably a "thinning out" of the stars before we reach the eleventh magnitude distance, at least in extra galactic regions. If we suppose that of the 100 millions of visible stars, 50 millions are scattered uniformly through a sphere, with a radius equal to the distance assumed for stars of the eleventh magnitude—the remaining 50 millions being included in the Milky Way—we have an average "unit parallax"* for these 50 millions of about 0·11″, which seems to indicate a "thinning out" of the stars towards the boundaries of the sidereal system. If this be so, we may conclude that the stars with a larger parallax than 0·11″ are exceptions to the general rule of stellar distribution, and form perhaps comparatively near neighbours of our sun. These near stars seen from the outskirts of the visible universe might perhaps form a small open cluster. Thus the parallax of α Centauri being 0·76″, the distance of a sixteenth magnitude star would be 760 times the distance of α Centauri, and it follows that the sun and α Centauri seen from a sixteenth magnitude star—equally distant from both—would appear as two faint stars about $4\frac{1}{2}$ minutes of arc apart.

The above results are of course based on the assumption that the faint telescopic stars lie at a distance indicated by their brightness. Such, however, may not be the case. Many of these small stars may be in reality absolutely small. The apparently close connection between bright and faint stars, as shown by photographs of the Milky Way near α Cygni and α Crucis, suggests that bright naked eye stars and faint telescopic objects may, in some cases at least, lie in the same region of space. If this be so, the

* That is, the parallax of a star as seen from its nearest neighbour.

difference in the size of these distant suns must be enormous, and would lead us to the conclusion that possibly the Milky Way may not lie so far from our system as has been generally supposed. If, as has been suggested, there is any extinction of light in the ether, the faintest stars cannot be placed at a distance corresponding to their apparent brightness.

Science Notes.

In a letter recently received from Prof. G. E. Hale, he says that the contract for the Yerkes 40-inch refractor has been given to Messrs. Alvan Clark, and that Mr. Clark is now at work upon the discs doing the rough grinding. Messrs. Warner and Swasey have been given the contract for the mounting, and they expect to have it set up in Chicago before the summer is over.

Mr. Burnham has definitely decided not to devote himself again to astronomy professionally, but he will be given every facility for using the great instrument.

Prof. G. E. Hale has recently obtained, at the Kenwood Observatory, Chicago, a photograph of the spectrum of a solar prominence, showing 74 bright lines in the ultra-violet between λ 3970 and λ 3630. A 4-inch grating was used on a 12-inch refracting telescope, with glass objectives for the collimator and telescope of the spectroscope. In the photograph obtained all the lines are shown which have been previously photographed by M. Deslandres, of the Paris Observatory, with apparatus in which no glass is used; and in addition to these, 32 lines appear which have not been previously photographed.

Science Gossip contains a highly interesting paper by Mr. P. L. Simmonds, F.L.S., on animal plagues. After giving some statistics with regard to the enormous numbers of human beings and cattle annually lost by death from snake-bites, or from lions, tigers, wolves, and crocodiles, he gives an account of the rabbit plague in Australia. Speaking of India, he says that in 1889, 25,204 persons were killed by wild animals and snakes—chiefly the latter. In Australia it is reckoned that kangaroos consume on an average as much grass as sheep; hence it is very important that their numbers should be reduced. But rabbits (introduced by Europeans) are the chief plague. The extent of the evil may be imagined from the fact that 15,000,000 rabbit skins have been exported from New South Wales in one year; and that in the thirteen years ending with 1889, 39,000,000 rabbit skins were exported from Victoria. The property destroyed by rabbits is estimated by millions of pounds. In spite of the determined efforts that have been made by colonial governments and private individuals, there are some districts where it has become a question whether the farmers can keep up the struggle with them. The fencing off of small districts with wire netting seems to be the best means that has been tried of keeping them out of a particular district.

Since Darwin's investigations on so-called "carnivorous plants," a great deal has been written on the habits and powers of these remarkable organisms, but the question how flies, &c., were dissolved and digested seems to have remained unsolved. It is now maintained that digestion in the case of carnivorous plants is due to the activity of certain micro-organisms, which are always present in the sap of the mature plant, and that their secretions are favourable to the development of such minute organisms.

Dr. Francis Galton and other eminent anthropologists have issued a circular letter on behalf of the committee appointed by the British Association, for an ethnographical survey of Great Britain. It is proposed to take certain typical villages and their surrounding districts and to record the physical types of the inhabitants, their current traditions, the peculiarities of dialect, the monuments and other remains of ancient cultivation, and historical evidence as to continuation of the race.

A correspondent (Sereno E. Bishop) writes to *Nature* from Honolulu (November 8th) to say that during the last three weeks there has been a remarkable renewal of the "afterglow." It seems as if the dust floating in the upper atmosphere, which produces the afterglows, had been added to. Is this owing to the August eruption in Alaska, which is said to have distributed volcanic ash at a distance of 250 miles? The writer says that no such afterglow has been seen since 1886, or three years after the Krakatão eruption.

The famous German Professor Rudolf Virchow receives this year the Royal Society's Copley medal for his researches in pathology and prehistoric archæology, Sir Joseph Hooker receives the Darwin medal, as being one of the earliest supporters of the author of "The Origin of Species," and Mr. J. N. Langley receives a Royal medal for his researches on the secreting glands and on the nervous system.

Norwich Castle, an ancient building of historical interest, has been acquired by the committee of the Norfolk and Norwich Museum with a view to the transfer of their valuable collections as soon as the castle has been fitted up for the purpose. When the scheme is completed, the trustees are to make over the building and collections to the Corporation, who have agreed to accept the trust, and to hold the castle and its contents for the benefit of the citizens of Norwich. It is to be hoped that the good example thus set may be followed in other places. The Castle Museum Committee are fortunate in having Lord Walsingham for their chairman. He is an ardent naturalist, whose important contributions to the British Museum of Natural History are well known.

From *The Geological Magazine* we learn that Bristol is following on the same lines. At a recent meeting of the shareholders of the Bristol Museum and Library a resolution was adopted for the transference of the institution to the Corporation of Bristol. By a generous offer of £3000 from Sir Charles Watken, together with a small endowment fund, the liabilities will be cleared off.

The December number of *The Field Club* contains the following story, from a correspondent, of a rat that has acquired the habit of catching trout: "Within a mile of where I now write, on the Braid Burn, which runs through Blackford Hill public park, Edinburgh, I have seen a rat—not the ordinary grey species, but the black, with short head, not unlike that of a guinea-pig—dive after and catch a trout, bring it to the bank, and devour it. An old quarryman, who worked by the stream, first told me of the rat's habit, and together we have watched him creep along the branch of an alder overhanging a small pool, sit immovable, as if part of the tree, until a trout swam within his ken, when, like a flash, he dived after his prey, and almost invariably succeeded in his sub-aquatic chase."

XUM

Not only is electricity being now largely used in the production of aluminium from clay, but in other directions also electricity is being made extremely serviceable. For example, the manufacture of caustic soda, which was hitherto a slow process, is being carried on from brine by the aid of electricity, chlorine and other chemical products being obtained at the same time. As compared with present methods, the new process is at least fifty per cent. cheaper, and much simpler. The chlorine, which is very valuable, is saved for the production of bleaching powder. It seems probable that the chemical industries of the country will be greatly modified and benefited by the electrical methods now being introduced.

At the recent anniversary meeting of the Royal Society, the president (Lord Kelvin) referred in his address to an extra number of the "Proceedings" (No. 310) which is devoted to a first report of the Water Research Committee on the present state of our knowledge concerning the bacteriology of water, by Professors Percy Frankland and Marshall Ward. This committee was appointed by the society, in alliance with the London County Council. The report is full of most valuable information regarding the vitality of micro-organisms in drinking water, to which in a large measure the spread of Asiatic cholera, typhoid fever, and other zymotic diseases is now known to be due.

Mr. W. H. Preece, the well-known electrician, has succeeded in sending a telephonic message from the shore of the Bristol Channel, near Cardiff, to the island of Flatholm, three miles off, without the intervention of a connecting wire. This truly wonderful result seems to open out a great vista of future possibilities.

A HIGHLY interesting discovery of human remains has lately been reported from the Riviera. The caves in which the bones were found were discovered in 1872 by a M. Riviere, and since that date explorations have been vigorously carried on. The skeletons that have been discovered belonged to a long-headed (dolichocephalic) race, and the individuals they represent were evidently strong and muscular. Three more skeletons were discovered early last year, one of which represented a tall man, whose height was about 6 feet 6 inches; with these bones were found necklaces made of fish bones, canine teeth of stags, shells, &c. Some of the stone implements found with the bones were finely worked, but none of them polished, and some of the bone implements were very rudely made. Many mammalion bones were also found, but none of extinct species, or even of reindeer. But the absence of polished stone implements seems to indicate an early period in the stone age—say the beginning of neolithic times. There is still one cave unexplored, and the Prince of Monaco, whose property it is, has given orders that the work of excavating it is to begin next spring. One curious fact about the human bones here discovered is, that those belonging to adults are all found to have been painted red with peroxide of manganese; and the Marquis de Nadaillay, who reports the discovery in *Science* (September 23rd), says that a similar custom was observed by some Indian tribes.

The remains of ancient lake-dwellings, well known in Scotland and Ireland under the name of "crannogs," are very scarce in England. But Dr. R. Munro, in the *Times* of October 24th, calls attention to a newly-discovered example in Somersetshire. The discovery was made by Mr. Arthur Bulleid, of Glastonbury, whose observations are of special interest. The site of this ancient lake-village is about a mile north of Glastonbury, on the road to the village of Godney. A number of low mounds were noticed here, each rising from one to two feet above the surrounding soil, and extending 20 to 30 feet across. Excavations having been made, some of the original piles were discovered. The total number of mounds is between sixty and seventy, and they extend over an area of some five acres. Each mound, it seems, contains a fireplace. The hearths were generally formed of large stone slabs, placed over a bed of clay, or of small stones embedded in it in the form of a pavement. An old seventeenth-century map of the district shows that it contained a lake called "The Meare Poole," into which three streams found their way. This pool was not far distant from the site of the present discovery. It is probable that the lake once covered a larger area. Bronze rings, fibulæ, a brooch, and a few decayed iron objects have been found here; pottery is abundant; also articles of bone and horn, and some flakes and cores of flint. Articles of "late Celtic" date predominate, and at present nothing Roman has turned up. It is to be hoped that this interesting site will in time be thoroughly excavated.

There has lately been some discussion in one of our evening papers on a question of considerable importance to "the masses," viz., whether tinned meats, shell-fish, fruits, &c., are sometimes poisonous, and what are the causes that produce the poison. One cause is supposed to be the lead used in some inferior kinds of solder. The lead is believed in this case to be dissolved by meat acids, or the acids of fruit, as the case may be. Another supposed cause is the presence of bacteria in meat, shell-fish, &c., owing to insufficient boiling before the tin is soldered up. Another and more obvious cause is the occasional cracking or breaking of a tin, so that air gets in, and that of course would start decomposition. It is comforting, however, to find that one writer denies the possibility of lead poisoning, and maintains that every precaution is taken by the leading American firms to secure complete sterilization by means of the hot bath. In cases where air has afterwards got in through a crack, the smell ought to be a sufficient indication of the fact. The deaths from eating tinned foods appear to be a very small percentage when the millions who use tinned eatables are taken into account.

WHAT IS A NEBULA?

By A. C. RANYARD.

IN the article under the above heading published in the October number, it was shown that nebulæ are as a general rule extremely transparent, and that the density of the larger nebulæ must be very small, the density of the Orion nebula being probably less than one ten thousand millionth of the density of our air at the sea level. The Orion nebula shines with a faint green light, giving a gaseous spectrum, and if it were a quiescent mass of gas we should expect the cooler outer layers to absorb the radiations given out by the glowing gas within, and its greenish light would consequently not reach us.

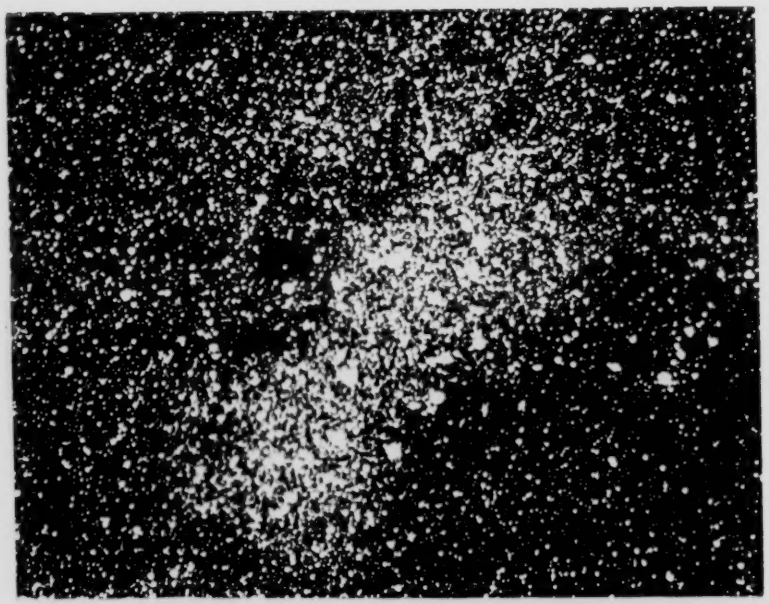
Again, the great transparency of the Orion and many other nebulæ would lead us to conclude that even its interior parts can radiate freely into space, and that consequently they would probably cool rapidly; but if the nebulous matter is cold, how can we account for its faint luminosity?

If we suppose a mass of hot gas consisting of a great variety of chemical elements to be projected into space, most of its chemical constituents would, as the gas cooled, be precipitated into a glowing mist, the particles of which

XUM

XUM

WEST.



NORTH.

NORTH.

WEST.

SOUTH.

The right hand picture represents a region of the MILKY WAY to the north of the Trifid Nebula, from a photograph taken by Prof. E. E. BARNARD at the Lick Observatory with a 6-inch camera of 31 inches focus. The centre of this photograph is situated at about 18h. 10m. R.A. — 20° Dec. Scale 1 inch = about 1° 50′. **The upper left hand picture shows the central part of the same photograph, enlarged about three diameters; and the lower left hand picture shows the central region as photographed by Dr. MAX WOLF, of Heidelberg.**

Printed by Morgan & Kidd, Richmond

would, as the cooling proceeded, cease to glow, but they would still be surrounded by the more volatile gaseous constituents of the original nebulous mass. We should expect to find the uncondensed gases arranging themselves round the liquid or solid particles, forming a sort of atmosphere about them, very loosely packed, owing to the small attracting power of the particles. The particles would be moving with the general velocity of the vapour from which they were condensed, each carrying around it an atmosphere of uncondensed gas of considerable diameter, compared with the diameter of the solid or liquid particle, and wherever two streams of the original nebulous matter impinged upon one another, we should have far more frequent collisions of the atmospheres surrounding the particles than collisions of the particles themselves. The collisions of the particles themselves, if moving with planetary velocity, as supposed by Mr. Lockyer in his meteoric hypothesis, would give rise to a continuous spectrum, but the much more frequent collisions of their atmospheres, would, it seems probable, give rise to a gaseous spectrum, even though the matter of the nebula were extremely cold.

Before endeavouring to make a further step in the

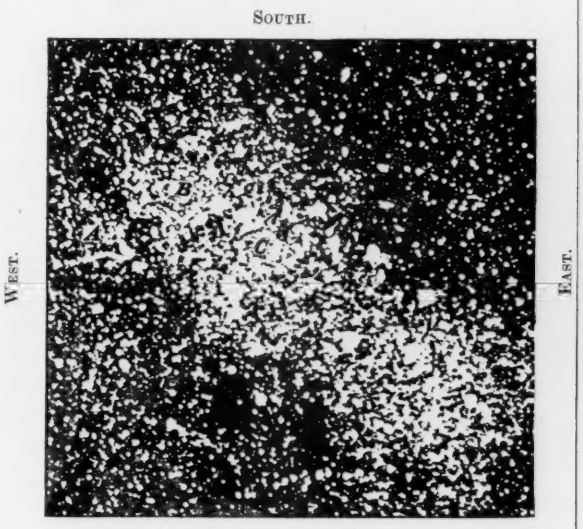


FIG. 1.—Block etched by a photographic process from the central region of Prof. Barnard's photograph, enlarged about three diameters.

enquiry "What is a Nebula?" I will ask the reader to devote a little time to a careful examination of the remarkable photographs reproduced in our plate. Near the centre of Prof. Barnard's large photograph is a bright nebulous patch, thickly strewn with stars, and within the bright region, or projected upon it, is a darker patch with straggling arms or projections, which appear to have sprung from the dark area and spread out in their upper parts somewhat after the manner of solar prominences, though on a vastly larger scale. Again, within the dark area there are two black or nearly black starless regions, which appear like holes in the stellar cluster and its associated nebulous matter, except that one star is seen projected upon the larger of the two black regions.

The question whether the dark structure is nearer to us than the bright nebulous cloud and its associated stars—that is, whether it is only by chance seen projected upon the bright background, or whether the dark structure is surrounded by the nebulous haze and stars, and is only partly seen through the bright nebulous matter—is one of very great interest and importance in determining the theory which we may be led to adopt in order to explain the phenomena observed.

The facts referred to in the paper on "Dark Structures in the Milky Way," published in the December number of KNOWLEDGE for 1891, would lead us to conclude that the dark and bright structures of the part of the Milky Way there described are all at about the same distance from us, and are intimately associated together. The dark arch and dark tree-like structures, referred to in the December number, 1891 (Fig. 5, page 232), spring from a large dark area in Sagittarius, about ten degrees to the south of the region shown at the centre of Prof. Barnard's photograph, which we are now discussing, and the dark structures there appear to have been projected into surrounding bright nebulous matter. Similarly, in the case now before us, the dark structures seem to be intimately associated with lines or streams of stars in the stellar cluster, and the stellar cluster appears to be associated with a general nebulosity which seems to be brightest where the stellar points cluster most thickly.

One of the most remarkable of these branching lines or streams of stars is situated between the dark structures marked *a* and *b* in Fig. 2. It is best seen in the enlarged copy of Prof. Barnard's photograph, and is marked with

FIG. 2.—Block etched by a photographic process from the central region of Prof. Barnard's photograph. The same scale as the original.

the letter A in Fig. 1, but it can be distinctly traced in Prof. Max Wolf's photograph. It seems to afford evidence of a stream of matter which has rushed outward from the dark region, for it forks or branches in a direction away from that region, as also do the dark structures marked *a* and *b* in Fig. 2, and the almost linear dark branching structure marked C in Fig. 1. So also does the dark structure marked *c* in Fig. 2, for it is connected with the central dark region by a narrow dark stem, which, after having attained a certain height, spreads into a broader head, from which diverge narrow branching streams which fork outwards. Stretching westward from the base of *c* is a remarkable line of stars, with an adjacent narrow black channel. In view of these facts, we are led to the conclusion that there is an intimate connection between the dark structures and the stellar cluster, and that the dark region is probably surrounded by bright nebulosity.

It seems to me that the easiest explanation of the two black holes is to assume that they correspond to the places where two dark structures similar to *a*, *b* or *c* (Fig. 2) stretch out from the central mass in a direction towards the observer, and that they reach to the surface of the

surrounding cluster and nebulosity, while the structures *a*, *b* and *c* are seen through a certain depth of nebulosity, so that they appear veiled and less black than the summits of the dark structures which extend in a direction towards us.

If we adopt this explanation of the facts observed, we are forced to conclude that the ejected matter, when it is first shot outwards from the central region, is dark or opaque, and that it afterwards becomes luminous and gives rise to the stellar points which we have spoken of as stars, though they may really correspond to considerable areas of flocculent nebulous matter, giving much less light, area for area, than the photosphere of our sun. According to Prof. E. C. Pickering's estimate of the sun's light in stellar magnitudes, our sun, if it were removed to a distance where it would appear to shine like a star of the fourteenth magnitude, would (if there were no absoption of light in its passage through space) have an apparent diameter of only the fifty-thousandth part of a second,* but the smallest stars shown have in these photographs an apparent diameter of at least fifteen seconds of arc, so that it is possible that the bright regions we are referring to, and which we have hitherto spoken of as stars, may have diameters many thousand times greater than that of our sun, and may be many million times less bright, area for area, than the solar photosphere.

The branching character of the dark prominence forms, and the spreading nature of their summits, indicates that they are projected into a resisting medium, and that in expanding they are doing work against resistance; consequently if the dark prominences are composed of gaseous matter, they must cool as they expand. It seems also highly probable that matter shot up from the interior of a cluster or nebula, which is cooling into space, would be hotter than the matter which has been in the exterior parts of the nebula or cluster for a considerable time. We are therefore, no doubt, warranted in concluding that the ejected matter, as it first issues in a hot condition, is dark and opaque, and that as it cools it becomes luminous and comparatively transparent, or transparent in the interspaces between highly luminous regions.

It seems to me that the phenomena we observe are very much what we might expect to see if a mass of mixed vapour at a high temperature were projected into a region occupied by cooler vapour, or any resisting cooler medium, such as a cloud of dust: the elements having the highest evaporating and melting points would first condense into a luminous mist, the particles of which would act like floating bodies on a stream, and be swept aside into the eddies and vortices surrounding the main current of the outrushing gas. To judge of large things by comparatively small, we see the same tendency to collect into flocculent masses in the willow-leaf and rice-grain structure of the solar photosphere, and in our own "mackerel" clouds in a gale of wind. According to my theory, the dark structures of the Milky Way and nebulous clusters are the stellar analogues of the solar spots.

When a large sunspot is near to the centre of the sun's disc, and we are able to look down into it, we do not see the heated central body of the sun, nor do we see the bright shell of photosphere which, it is only reasonable to assume, is shining both upwards and downwards on the opposite side of the sun. We are, no doubt, looking into a deep mass of heated vapour, and the wave-lengths, which are radiated by the hotter and deeper strata, are entirely swallowed up and absorbed by cooler vapour at a higher level, or, to speak with greater caution, such a large proportion of the radiated energy is swallowed up that the intensely heated gaseous mass looks comparatively black beside the relatively cooler incandescent mist into which the outer gaseous matter condenses where it can radiate freely into space; and this is the case even though a portion of the light of the incandescent mist is absorbed by vapours above it, as is evident from the channels cut out of its continuous spectrum. In the same manner, we should expect the intensely heated gas issuing from the hotter parts of a nebula or cluster to appear black and opaque compared with the relatively cooler matter composing the outer parts of the nebulous mass or cluster. In the case of the sun, where there is a rapid fall in the temperature as we pass upward through a few thousand miles, we should expect the incandescent clouds of condensing vapour to form a comparatively thin spherical layer corresponding to the photosphere; but in the case of vast streams of heated gas which are carried to enormous distances from the heated region from which they are ejected, before they become sufficiently cooled for any part of the constituent vapours to condense into a white-hot mist, the conditions of cooling would be altogether different. The condensing gas is probably much rarer than in the sun at the level of the photosphere, and it seems not improbable that in the nebula the regions of most rapid cooling and condensation would be intimately associated with the vortices formed in the surrounding medium, where the most rapid contact of heated and cooled material would take place, and where the most rapid compression and expansion of gases causing changes of temperature would also be localized. Such at least seems to me to be the most probable solution of the great riddle presented to us in the complicated phenomena observed.

It seems certain that the stars of irregular star-clusters cannot be moving under the action of gravity so as to form a permanent system with motions about the common centre of gravity of the cluster. It is possible that the individual stars of such a cluster might exist for a limited time until a collision took place and they were shot forth again on a new orbit; but it is also possible that the stars of such clusters are not bodies similar to our sun, but that they correspond to regions of rapid condensation where a white-hot mist is formed in a gaseous medium pervading the whole region of the cluster. The curvilinear streams of stars with forking branches which have been noted in so many clusters (see Miss Clerke's "System of the Stars," p. 243), seem to indicate that they are intimately associated with streams of gaseous matter projected into a resisting medium, and recent photographs also seem to point to the conclusion that all star clusters are nebulous.

* See *The Old and New Astronomy*, page 777.

THE LATE MR. MATTIEU WILLIAMS.

MANY of our readers will hear with sincere regret of the death of Mr. W. Mattieu Williams, who was formerly, during the editorship of Mr. Proctor, a very constant contributor to the pages of KNOWLEDGE. Mr. Williams was born in 1820, and was at the time of his death in his seventy-third year. He left school at the early age of eleven, and was apprenticed to a Mr. Street, an optical instrument maker in London. During this hard-working period of his boyish life he attended a mechanics' institute in the evenings, and taught himself French and German. On coming of age he inherited a small sum of money, which enabled him to go to Edinburgh to study chemistry, and he subsequently further continued his education by making a tour through the principal countries of Europe on foot. In 1854, on

the foundation of the Birmingham and Midland Institute, Mr. Williams was appointed master of the industrial department, a position in which he greatly developed his powers of lecturing. Besides his work at the institute he

The late Mr. W. MATTIEU WILLIAMS, from a photograph taken shortly before his death.

practised as a consulting chemist and commenced writing science articles.

During one of his summer holidays he visited Norway, and walked through a considerable portion of the country, then comparatively little known to English tourists. He published the results of his experiences in 1859, under the title of "Through Norway with a Knapsack," a book which was illustrated by the late Mr. John Steeple from sketches made by Mr. Williams during his walk. It passed through more than one edition. At a later period he again described Norwegian travelling in a book entitled "Through Norway with Ladies."

In 1870 Mr. Williams published a volume of philosophical speculations on the cause of the sun's heat, and other cosmical problems. The volume was issued under the title "The Fuel of the Sun," and was widely read. Mr. Williams assumes the existence of a universal atmosphere, and that the density of the atmospheres surrounding the various planets depends upon the amount of the universal atmosphere which the planets can, by reason of their mass, condense about their surfaces. Though none of Mr. Williams' speculations have been generally adopted by astronomers, the book is very suggestive, and many able writers have acknowledged their indebtedness to it.

Mr. Williams was a lucid and most interesting lecturer on the chemistry of common life. In the early volumes of KNOWLEDGE he wrote an excellent series of articles under the title "The Chemistry of Cookery," which were widely quoted at the time, and were afterwards collected and published as a small volume. He also wrote "Science in Short Chapters," a "Simple Treatise on Heat," the "History of the Manufacture of Iron and Steel," and an excellent little book entitled "The Philosophy of Clothing." He was a frequent contributor to the *Gentleman's Magazine* on scientific subjects, and was the author of a system of shorthand entitled "Shorthand for Everybody." At the time of his death he was at work at a book upon the brain, which it is understood will shortly be published by Messrs. Chatto and Windus. He leaves a widow and three sons.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

To the Editor of KNOWLEDGE.

SIR,—Having noticed in your last number some remarks upon the so-called "horned toads" of Mexico, you will perhaps allow me to mention my experience of their habits.

While staying at San Diego, in Southern California, I drove some miles inland, on the borders of Mexico, with my son. On a sandy waste we saw numbers of these toads, running with great rapidity, and burying themselves in the sand by means of a lateral wriggling movement. We captured three, and placed them in the empty basin of a fountain until we left for San Francisco, *en route* for England. They soon became very tame; but the largest (presumably a male) was so troublesome in spirting out what looked like blood that we left him behind. The other two we brought to England, where they lived for several months.

The blood appeared to come from small orifices directly above and behind the eyes, and the discharge was so forcible and profuse as to cover my son's naked fore-arm quite up to the elbow. Great prostration followed, and lasted for a day or two.

The "horned toad" has the chameleon-like faculty of rapidly changing his colour to that of the soil upon which he may be placed.

The two smaller animals never exhibited the "spirting."

Yours faithfully,

Wilmer Road, Bradford, G. W. GRABHAM, M.D. (Lond.)
December 6th, 1892.

To the Editor of KNOWLEDGE.

Mackay, Queensland,
October 15th, 1892.

DEAR SIR,—In the September, 1892, number of KNOWLEDGE, in an article by R. Lydekker on "The Oldest Fishes and their Fins," the *Ceratodus Forsteri* of Queensland is repeatedly called "Barramund*a*." The aboriginal word Barramund*i* simply means large fish, and is indiscriminately applied throughout Australia to whatever fish happens to be the largest in that particular locality; but the name should be legitimately restricted to the *Osteoglossum Leichardti*, Leichardt having been the first to describe this fish by that name. I append tracings of *Osteoglossum L.* and *Ceratodus F.*, and beg to refer Mr. Lydekker to Saville Kent's "Food-fishes of Queensland," 1889, which could probably be obtained from the Queensland Agent-General in London.

Your obedient servant,

J. EWEN DAVIDSON.

PERIODICAL COMET DUE IN 1893.

To the Editor of KNOWLEDGE.

SIR,—Only one of the known periodical comets is due to return next year. This was discovered by Mr. Finlay, at the Cape of Good Hope, on the 26th of September, 1886, and passed its perihelion on the 22nd of November following. As soon as the orbit was calculated by Dr. Holetschek, it was noticed that the elements bore a striking resemblance to those of the comet of De Vico, which, after its discovery in 1844, was found to be moving in an elliptic orbit, with a period of only about five and a half years, but

has not since been seen, unless possibly once by the late M. Goldschmidt, of Paris, on the 16th of May, 1855. The orbit of De Vico's comet is very similar (so far as it could be determined by Le Verrier from all the observations available) to that of one discovered by La Hire in 1678, and it is not unlikely that the comets are identical. It was for some time thought that Finlay's comet might be identical with De Vico's; but the definitive calculation of Prof. Krüger (*Astronomische Nachrichten*, No. 2781) showed that that view was untenable. The orbits of both comets, however, agree in having very small inclinations to the ecliptic, and perihelion distances from the sun exceeding by only about a sixth part the mean distance of the earth. According to Prof. Krüger's calculations, the period of Finlay's comet is about 6·67 years, so that a return will be due in the summer of 1893. It does not appear that it was ever seen before its discovery in 1886.

Blackheath, Yours faithfully,
December 3rd, 1892. W. T. LYNN.

THEORY OF THE SUN.

To the Editor of KNOWLEDGE.

SIR,—In the excellent notice of my theory published in the last (December) number of your magazine, Miss Agnes M. Clerke remarks that if my explanation of the prominences as *evanescent illuminations caused by rapidly propagated chemical action in tranquil matter* were true, the prominences would give a continuous spectrum. Hydrogen, she says, "ignited by combustion shows no trace of its characteristic lines." That objection, though in contradiction with a generally accepted statement of Plücker ("Pogg. Ann.," 116, p. 48) that the flame of a mixture of oxygen and hydrogen, when the latter is slightly in excess shows the two lines Hα and Hβ, seems at first to be strengthened by a recent note of Prof. Liveing "*On Plücker's supposed detection of the Line-Spectrum of Hydrogen in the Oxy-hydrogen Flame*" (*Phil. Mag.*, Oct. 1892). But the negative results obtained by Prof. Liveing (suppose they prove really that such an eminent observer as Plücker has mistaken lithium and zinc lines for hydrogen) have, I think, no sufficient bearing on the question moved by Miss Clerke. They only prove, says Prof. Liveing himself, "that the temperature of the oxy-hydrogen flame alone is not sufficient to cause hydrogen to emit the rays we see produced by an electric discharge in that gas."

If therefore we assume the temperature in prominences higher than in the oxy-hydrogen flames of Prof. Liveing, we see no reason why chemical action should not cause the hydrogen to produce lines there. But there is still a second reason why the remarkable statement of Prof. Liveing has no direct bearing on the constitution of prominences; and that reason is, that whatever may be the chemical processes in the solar atmosphere (oxygen and water having never been surely detected there), they cannot have any resemblance with the oxy-hydrogen flames tested by Prof. Liveing.

My explanation of the prominence lines as produced by chemical action is, moreover, strongly supported by the countless well-known observations of lines in flames burning by chemical processes. I need not insist on that well-established fact, but I only wish to state how unexpectedly the recent work of E. Wiedemann, R. V. Helmholtz, W. H. Julius, and others on "luminescence," and especially that of E. Pringsheim on the line spectrum of sodium-vapour, have given a strong support to my idea. According to the experiments of W. Siemens ("Wied. Ann.," 18, p. 311) and Pringsheim ("Wied. Ann.," 45, p. 428, 1892), *heat alone is not sufficient to cause gases to produce lines; either electricity or chemical action must co-operate.* No clearer experimental illustration could have been given of the meaning of my theory of the luminous phenomena in the solar atmosphere.

May I add here that among the numerous observations of prominences published since my theory was written, there are again a great many in close agreement with my theory of a tranquil sun. So, for instance, I found in the "Memoire della Societa degli Spettrosi Italiani," vol. 21, 1892, the description of an enormous prominence, which, according to M. T. Fenyi, could not possibly have been caused by a material eruption or explosion, but seemed to that eminent Hungarian observer produced and very rapidly moving by a sudden and local outbreak of "electricity."

I finish with an expression of gratitude to Miss Clerke and to you for the trouble you have taken in noticing my theory. Dr. A. BREDER, Jz.

Delft (Holland), Dec. 20th, 1892.

[It seems to me that prominences of the eruptive type afford evidence of actual motion which can hardly be doubted. Not only do we observe very striking displacements of the prominence lines in the spectrum which indicate motion of the luminous matter in the line of sight away from or towards the observer, but we actually observe rapid motion across the line of sight. The velocity of the motion corresponds roughly with the velocity of a projectile shot upwards under the influence of solar gravity, being sometimes a little *more rapid* than projectile motion; as we should expect if the matter shot upwards was passing through a resisting medium, because in being shot upwards it would need to pass through the lower portion of its upward path more rapidly than a projectile moving in free space, which is shot to the same height above the sun.

I would refer Dr. Brester to papers of mine and of the late Mr. Proctor, dealing with the upward motion of prominences, published in the *Monthly Notices of the Royal Astronomical Society*, Vol. XLI., p. 77. On the other hand, the motion of eruptive prominences is sometimes a little slower than free projectile motion would be, probably because the prominence observed is either on this side or on the more remote side of the sun's limb, and the matter is not being shot upwards at right angles to our line of sight. If the phenomenon observed were due to the mere change in place of electrical illumination, we should expect the velocities observed to correspond with electrical velocities, rather than with the velocities of projectiles moving under solar gravity. On the other hand, the quiescent cloud-like prominences sometimes appear to form, and grow larger, without any visible connection with the lower chromosphere. It may be that the lines of connection (the stems of the banyan-trees, as Prof. Young aptly calls them) are so faint or thin that we do not notice them, or that there is an electrical or other physical change going on which renders matter luminous that previously existed in the same region in a non-luminous state.

Dr. Brester's letter was received just as KNOWLEDGE was going to press, so that there has been no time to submit it to Miss Clerke.—A. C. RANYARD.]

LEMURS.

By R. LYDEKKER, B.A.Cantab.

IN a previous article we have had occasion to refer to Africa as an archaic kind of land containing types of mammalian life which, while formerly widely spread over the Old World, are now restricted to that continent. If this preservation of ancient types be

highly characteristic of continental Africa, still more markedly is it so of the large island of Madagascar, lying off its eastern coast. In Africa itself many of the ancient types are more or less closely allied to other living mammals, and most of them belong to orders which are abundantly represented in other parts of the world. Very different is, however, the case with Madagascar, of which the great peculiarity is that it has preserved to us a whole fauna of those remarkable animals known as lemurs, which are represented elsewhere only in Africa and the Oriental region, and there by a comparatively small number of species belonging to genera totally distinct from those found in Madagascar. To put the matter more clearly, it may be stated that out of a total of thirteen genera of living lemurs no less than eight are absolutely confined to the island of Madagascar, while the remaining five are distributed over Africa, India, and the Malayan islands; two out of the five being African, one Indian, and two Malayan. The disproportion is, however, not even adequately expressed by the above statement, since, while most of the Malagasy genera are represented by a considerable number of species, of those found in other regions only one has more than two species, while two out of the other four have but a single species each. Lemurs are, indeed, in every sense the characteristic mammals of Madagascar, being far more common in its woods and coppices than are squirrels in those of this country. So common are they said to be in certain parts of the island that, according to the French traveller, M. Grandidier, it is impossible to beat through a single copse without turning out at least one of these strange creatures.

In order to arrive at the true reason of the present distribution of any group of animals, it is always necessary to consult the records of geology; and it appears from these that while lemurs were unknown both in Europe and North America during the pliocene and miocene divisions of the tertiary period, when we reach the upper part of the eocene epoch we find their remains occurring in company with those of the extinct anoplotheres and palæotheres, or other allied animals, in both the eastern and western continents. It is, however, hardly necessary to observe that the whole of these early lemurs belonged to genera which are quite distinct from any of those living at the present day, although one of them appears to have nearly been allied to the African group.

The discovery of these extinct lemurs, which is but comparatively modern, at once reveals the fact that this group of animals is a very ancient one, which was formerly widely spread over the globe, and was represented by at least one species in our own island. Not many years ago it was sought to explain the present peculiar distribution of lemurs by the supposition that a large island or continent formerly existed in the Indian Ocean; and the name Lemuria was suggested, appropriately enough, for this hypothetical land. From this presumed ancestral home it was considered that the lemurs had spread on all sides, some to find a refuge in the Malayan islands, others in the forests of Ceylon and southern India, but the larger number in Madagascar and Africa. Unfortunately, however, for a very pretty theory, the geologists had a word to say on the matter; and this word was to the effect that Lemuria could not possibly have existed at the time its presence was required for the needs of the theory.

With our fuller knowledge of fossil lemurs any such hypothetical land is, however, quite unnecessary to explain the present distribution of the group. At or about the time these animals existed in Europe there is little doubt that they were also spread over Africa, which there is good evidence to show was formerly connected by land with Madagascar. We do not, indeed, yet know how the ancient lemurs of Europe got into Africa, but when once there it is certain that they were ultimately cut off from Europe by a sea which stretched from the Atlantic to the Bay of Bengal in upper eocene times. For some time afterwards, during which Africa and Madagascar still had a free communication, the large mammals characteristic of miocene Europe were unknown in the lands to the south of this great sea, where lemurs and other lowly animals flourished in security. During some portion of this period Madagascar must have become separated from Africa, while an upheaval of land once more brought Africa into connection with Europe and Asia, and thus allowed it to be overrun by the great hoofed and carnivorous mammals which had hitherto existed only to the north of the dividing sea. This incursion of large quadrupeds at once put a final stop to the supremacy of the lemurs in Africa, where only a few species have since managed to survive by the aid of their nocturnal habits. In Madagascar, however, where there are still no large quadrupeds, and where the only carnivores are certain civet-like animals, the lemurs have continued to flourish in full exuberance, and the existing state of that island thus offers to our view a picture of what must have been the condition of Africa previous to the advent of its present fauna from the north. The few lemurs now inhabiting the Indian and Malayan region are, doubtless, also survivors from the original central home of the group, which have found safety in the dense forests of the regions they inhabit.

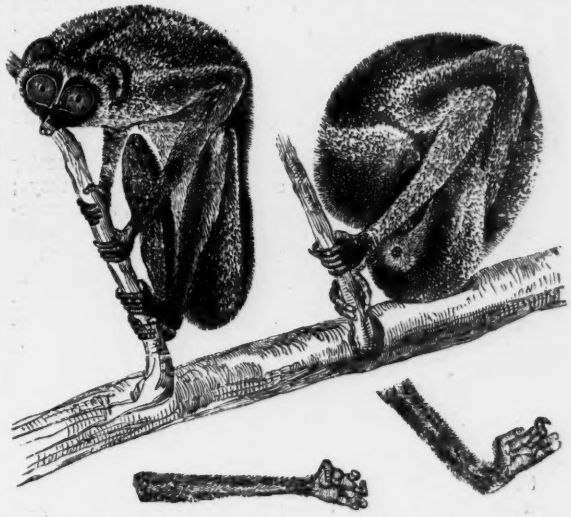


FIG. 1.—The Slender Loris, in waking and sleeping postures, with figures of the arm and leg. (From Sir J. E. Tennent's "Ceylon.") *

A good deal more might be said on the subject of the past and present distribution of lemurs, but by this time the reader will probably be impatient to know something of the characteristics of the animals thus designated by naturalists. Of course comparatively little can be said on this subject in an article of the present length, and it unfortunately happens that the lemurs, as a whole, do not present any very strongly marked single external feature by which they can be distinguished at a glance from all other mammals. It is, however, only with some of the lower monkeys of the New World that they could possibly be confounded by observant persons (although we have heard

* We are indebted to Messrs. Longmans for the use of this figure.

of some members of the family being mistaken for sloths); but the distinct geographical distribution of the two groups renders it unlikely that any confusion is likely to arise between them. The nearest relations of the lemurs are undoubtedly the monkeys, and most naturalists in this country are now agreed in regarding the former as representing a primitive group of the order (*Primates*) which includes the latter. Lemurs may always be distinguished from monkeys and apes by certain features in their skulls, as well as by several peculiarities in their internal structure; but as these require a certain amount of anatomical knowledge for their proper comprehension, we must ask our readers to take it on trust that such differences do exist. Externally lemurs differ from ordinary monkeys by their more or less fox-like and immobile countenances, but since the marmosets of South America (which are a lowly type of monkey) resemble them in this respect, this character does not afford an absolute distinction between the two groups. All lemurs are further characterized by having the second toe terminating in a long pointed claw, as shown in the right hand lower figure of our first illustration, whereas in ordinary monkeys the same toe has a flattened nail. Unfortunately, however, the marmosets have also a pointed claw on the toe in question, so that this character does not afford an absolute point of distinction between the two. On examining the upper teeth of the lemurs it will, however, be found that, except in the aye-aye of Madagascar, the first pair of incisor or front teeth are separated from one another in the middle line by a distinct gap, whereas in all monkeys they are, as in ourselves, in contact. Now as the aye-aye differs from all monkeys in having its first upper incisors of the chisel-like form characteristic of rodents (rats, beavers, &c.), the upper front teeth of the lemurs will serve to distinguish them absolutely from the whole of the monkeys.

In appearance the various kinds of lemurs differ greatly from one another, some of them looking not unlike monkeys; while others, as the one represented in Fig. 1, are characterized by their long and slender limbs, enormous eyes, and general ghostly form. Then, again, while some of them are furnished with long tails, others are destitute of these appendages; and the common cat-lemur of Madagascar is distinguished from all the rest by the bold alternating rings of black and white with which the tail is ornamented. The last-named species is further peculiar in living chiefly among rocks, whereas the others are arboreal and mainly nocturnal in their habits. It is from these nocturnal habits, coupled with the large eyes, ghostly appearance, and stealthy movements, characteristic of many of the species, that Linnæus was induced to propose the name of lemurs (from the Latin term for evil spirits) for this group of animals—a name which, in the absence of any vernacular title, has been adopted as their ordinary designation.

None of the lemurs are of large size, the length of the head and body in the largest species being only about two feet, and some of them are not larger than rats. They are all excellent climbers, and the majority spend the day sleeping either in the hole of a tree, in a specially constructed nest, or rolled up in a ball after the manner shown in our first illustration. Their food consists of leaves and fruits, birds and the eggs, reptiles and insects, and occasionally honey or sugar-cane; and most of them spend the whole of their time in trees, rarely, if ever, descending to the ground. Some of the larger species inhabiting Madagascar are, however, an exception in this respect, as well as in their diurnal habits, and they may sometimes be observed in numbers jumping across the plains from wood to wood in their own peculiar fashion, when it is necessary to seek fresh food. From the structure of their brains and other parts of their organization, it is evident that the lemurs hold a very low place in the mammalian class, although their near relatives, the monkeys and apes, occupy the highest position. It is probable, indeed, that the modern lemurs are the descendants of the ancient ancestral stock from which monkeys have originated, and since they themselves are also nearly related to the so-called insectivores (shrews, moles, hedgehogs, &c.), while the latter may have been directly descended from marsupials (opossums, &c.), we see how very close is the connection between the very highest and the very lowest representatives of the mammalian class. The low position of the lemurs in the zoological scale is in harmony with their antiquity and their peculiar geographical distribution, and it is noteworthy that both in Madagascar and in Africa lemurs are accompanied by certain insectivores of a very low degree of organization, and unlike those found in any other part of the world.

The limits of this article render our notice of the various kinds of lemurs necessarily very brief, and our chief attention will be directed to some of the more peculiar and interesting forms. Among the Madagascar lemurs are included a group known as indris, or, in the vernacular, sifakas, and containing the largest of all these animals. These sifakas are distinguished by the circumstance that all the toes of the foot, except the first, are united together at their bases; and they are further characterized by their parti-coloured fur, in which white, black, and various shades of brown and orange predominate. Most of them have long tails, but in one species this appendage is represented by a mere stump. They live in small parties in the woods of Madagascar, and feed entirely upon vegetable substances. By the aid of their powerful limbs they are able to take enormous flying leaps—sometimes as much as thirty feet in length—from tree to tree, and when passing from one clump of trees to another on the ground they hop on their hind limbs, with their arms raised above their heads, in a series of short jumps, when they are said to present the most ludicrous and grotesque appearance. They are largely diurnal in their habits, although sleeping during the heat of the day.

The true lemurs, which are likewise confined to Madagascar and some of the adjacent Comoro islands, differ from the sifakas in having thirty-six in place of thirty teeth, by their perfectly free toes, and their less elongated hind limbs. They all have long tails, and the best known species is the above-mentioned cat, or ring-tailed lemur, easily recognized by the feature from which it derives its second name. This animal, which is often exhibited in menageries, is about the size of a domestic cat, and is peculiar in frequenting rocks rather than trees, in at least certain districts in Madagascar. The black lemur, in which the male is black and the female red, is a nearly allied species; and there are also several others. The females of these lemurs have a peculiar habit of carrying their young clinging to the under surface of their body, with the head on one side and the tail on the other; but this strange position is only maintained for a certain time, after which the young creature mounts upon its parent's back, where it remains until able to shift for itself.

A third group is formed by the galagos, which differ from the true lemurs in having two of the bones of the ankle greatly elongated, so as to make this segment of the limb much longer than ordinary. They all have long and bushy tails, and are mostly of small size, some of them being even smaller than a rat. The galagos are divided into two groups—one confined to Madagascar and the other to Africa.

The former, or dormouse lemurs, are peculiar in that during the hot dry season several of the species undergo a kind of hiberhation, coiled up in the hollow of some tree, and in order to prepare themselves for such a protracted fast they accumulate on their bodies a large store of fat. The true African galagos, in addition to other features, differ from the last in that their large ears are capable of being partially folded up, somewhat after the fashion obtaining in the common long-eared bat. Like the dormouse lemurs, they are purely nocturnal, and when on the ground they hop after the manner of kangaroos, the elongation of the bones of the ankle doubtless subserving this kind of movement.

Widely different from all the above are the curious slow-lemurs of Asia and Africa, of which an Asiatic species is represented in Fig. 1. These lemurs are characterized by the index finger of the hand being either very short or rudimentary, and likewise by their tail being similarly abbreviated. The Asiatic representatives of this group, of which there are two genera and about four species, have the usual three joints to the index finger, which is, however, extremely short, and no trace of a tail. It was one of these lemurs which doubtless suggested to Linnæus his name for the whole group, as their movements are slow and deliberate in the extreme, their eyes large, and their habits completely nocturnal. The Asiatic forms are known by the name of loris. The common loris, with some allied species, extends from Burma through the Malayan region to Siam and Cochin China, and is a solitary animal inhabiting the depths of the forests. The strange and weird little animal represented in our first illustration is an inhabitant of southern India, and is commonly known as the slender loris. It differs from the common loris by its much larger eyes, which are separated from one another only by a very thin partition, as well as by its slender body and limbs; and in consequence of these and other points of difference is referred by naturalists to a distinct genus, of which it is the sole representative. This beautiful little creature is about the size of a squirrel and is of a yellowish-brown colour. It occurs in the forests, usually in pairs. Sir E. Tennent observes that "the naturally slow motion of its limbs enables the loris to approach its prey so stealthily that it seizes birds before they can be alarmed by its presence. During the day, the one which I kept was usually asleep in the strange position represented in the figure; its perch firmly grasped with both hands, its back curved into a ball of soft fur, and its head hidden deep between its legs. The singularly large and intense eyes of the loris have attracted the attention of the Singhalese, who capture the creature for the purpose of extracting them as charms and love-potions, and they are said to effect this by holding the little animal to the fire till the eyeballs burst." I once brought a pair of these little creatures from Madras to Calcutta, and during the voyage they lived chiefly on plantains and bread-and-milk.

In West Africa the slow-lemurs are represented by the potto and the smaller awantibo, both of which differ from the loris by the reduction of the index finger to a mere stump, and also by the presence of a distinct tail, which is of greater length in the former than in the latter species. These animals resemble their Asiatic cousins in their habits, but are even more deliberate in their movements; and while the potto appears to be not uncommon, the awantibo is of extreme rarity.

The whole of the preceding species are included by naturalists in a single family, but the two following representatives of the group are so different from all the others that each is made the type of a distinct family. The first of these two aberrant creatures is the weird tarsier, of the

FIG. 2.—The Tarsier. (From Guillemard's "Cruise of the Marchesa.")*

forests of Sumatra, Borneo, Celebes, and some of the Philippine islands. This animal derives its name from its greatly elongated ankle (*tarsus*), and is rather smaller than an ordinary squirrel, with large ears, enormous eyes, and a long tufted tail. Dr. Guillemard, who when in Celebes was fortunate enough to obtain a living tarsier, writes that "these little creatures, which are arboreal and of nocturnal habits, are about the size of a small rat, and are covered with remarkably thick woolly fur, which is very short. The tail is long and covered with hair at the root and tip, while the middle portion of it is nearly bare. The eyes are enormous, and indeed seem, together with the equally large ears, to constitute the greater part of the face, for the nose and jaw are very small, and the latter is set on, like that of a pug dog, almost at a right angle. The hind limb at once attracts attention from the great length of the tarsal bones, and the hand is equally noticeable for its length, the curious claws with which it is provided, and the extraordinary disc-shaped pulps on the palmar surface of the fingers, which probably enable the animal to retain its hold in almost any position. This weird-looking little creature we were unable to keep long in captivity, for we could not get it to eat the cockroaches which were almost the only food with which we could supply it."

Our brief account of the lemurs appropriately closes with the strangest of them all—the now well-known aye-aye of Madagascar. This remarkable animal, whose systematic position was long a puzzle to naturalists, was discovered as far back as 1780, but for eighty years after that was only known in Europe by the single specimen then obtained. The aye-aye differs from all other lemurs in

* Messrs. Murray have kindly lent us this figure.

having but eighteen teeth, but its most marked peculiarity is to be found in the circumstance that the single pair of front or incisor teeth in each jaw have chisel-shaped crowns like those of rats and beavers, and grow continuously throughout the life of their owner. Another peculiarity occurs in the extremely long and attenuated third finger of the hand, which surpasses all the others in length, although the whole hand is remarkably elongated. It also differs from other lemurs in that all the toes of the foot, with the exception of the first, have pointed claws, and thus resemble the second toe of the ordinary kinds. In size the aye-aye may be compared to a cat, and it has a rounded and somewhat cat-like head, with a short face, and large naked ears. The tail is long and bushy, and the general colour of the fur dark brown.

The aye-aye represents the extreme development of the lemur type, and it is evident that its peculiarities of structure are correlated with equally well-marked traits of habit. Unfortunately, however, from the nocturnal habits and rarity of the creature itself, as well as from the absence of a sufficient number of competent observers in its native haunts, we are by no means so well acquainted with the habits of this strange creature as is desirable. It appears, however, that the aye-ayes live either in pairs or alone in the bamboo forests of Madagascar, and that they are in the habit of constructing ball-like nests of leaves placed in the forks of trees, to which they retire for their diurnal slumber. The strong incisor teeth are certainly used for ripping up the hard external cases of the sugar-canes, on which these animals delight to feed; and it is said that they are likewise employed to tear away the bark and wood from the trunks of trees, and thus expose the burrows of wood-eating larvæ, which are then extracted by the aid of the thin middle finger. If any of our readers who may have friends living in Madagascar can induce them to try and obtain more particulars in regard to the aye-aye, they will be conferring a real benefit on science.

THE FACE OF THE SKY FOR JANUARY.

By HERBERT SADLER, F.R.A.S.

SOLAR spots and faculæ show no diminution in number. The following are conveniently observable minima of two Algol-type variables :—Algol, January 8th, 10h. 35m. P.M.; January 11th, 7h. 24m. P.M.; January 14th, 4h. 13m. P.M.; January 29th, 0h. 17m. A.M.; January 31st, 9h. 6m. P.M. U Cephei, January 3rd, 7h. 17m. P.M.; January 8th, 6h. 57m. P.M.; January 13th, 6h. 37m. P.M.; January 18th, 6h. 16m. P.M.; January 23rd, 5h. 56m. P.M.; January 28th, 5h. 36m. P.M. A maximum of the beautiful red variable U Orionis is due on the 16th.

Mercury is a morning star throughout the month, but owing to his great southern declination he will be liable to be obscured by mists near the horizon. He rises on the 1st at 6h. 18m. A.M., or 1h. 50m. before the Sun, with a southern declination of 21° 23′, and an apparent diameter of $6\frac{1}{2}''$, $\frac{65}{100}$ths of the disc being illuminated. On the 7th he rises at 6h. 34m. A.M., or 1h. 33m. before the Sun, with a southern declination of 22° 37′, and an apparent diameter of $5\frac{3}{4}''$, $\frac{76}{100}$ths of the disc being illuminated. On the 12th he rises at 6h. 46m. A.M., or 1h. 18m. before the Sun, with a southern declination of 23° 19′, and an apparent diameter of $5\frac{1}{2}''$, $\frac{82}{100}$ths of the disc being illuminated. On the 17th he rises at 7h. A.M., or 1h. before the Sun, with a southern declination of 23° 34′, and an apparent diameter of $5\frac{1}{2}''$, $\frac{87}{100}$ths of the disc being illuminated. After this he approaches the Sun too closely to be observed. He is at his greatest western elongation ($22\frac{3}{4}°$) on the 1st. During the time he is visible he passes from Ophiuchus into Sagittarius, without approaching any very conspicuous star.

Venus is a morning star, but is rapidly decreasing in brightness. She rises on the 1st at 5h. 46m. A.M., or 2h. 22m. before the Sun, with a southern declination of 21° 10′, and an apparent diameter of $11\frac{3}{4}''$, $\frac{87}{100}$ths of the disc being illuminated, and her brightness being about what it was at the end of last January. On the 12th she rises at 6h. 13m. A.M., or 1h. 51m. before the Sun, with a southern declination of 22° 40′, and an apparent diameter of $11\frac{1}{2}''$, $\frac{89}{100}$ths of the disc being illuminated. On the 31st she rises at 6h. 38m. A.M., or 1h. 5m. before the Sun, with a southern declination of 22° 0″, and an apparent diameter of $10\frac{3}{4}''$, $\frac{93}{100}$ths of the disc being illuminated. During the month she passes through Ophiuchus into Sagittarius, but without approaching any conspicuous star very closely.

Mars is still visible in the evening, but is now getting a very insignificant object in size, and rapidly decreasing in brightness. On the 1st he sets at 11h. 34m. P.M., with a northern declination of 1° 2′, and an apparent diameter of 7·6″. He is still markedly gibbous. On the 15th he sets at 11h. 30m. P.M., with a northern declination of 5° 0′, and an apparent diameter of 7·1″. On the 31st he sets at 11h. 31m. P.M., with a northern declination of 9° 14′, and an apparent diameter of $6\frac{1}{4}''$. He describes a direct path through Pisces during the month. On the evening of New Year's Day he is about 3′ north of the 6·4 magnitude star Ll 261. At about 5h. 40m. P.M. on the 14th he will probably occult the 6th magnitude star Ll 1299.

Jupiter is still the most conspicuous object in the evening sky. On the 1st he sets at 0h. 47m. A.M., with a northern declination of 5° 4′, and an apparent equatorial diameter of $40\frac{3}{4}''$. On the 31st he sets at 11h. 6m. P.M., with a northern declination of 6° 33′, and an apparent equatorial diameter of 37″. During the month he describes a short direct path in Pisces. On the evening of the 8th he will be about $\frac{1}{4}°$ north of the $5\frac{1}{2}$ magnitude star 80 Piscium. On the 23rd he will be occulted by the Moon, but the phenomenon will not be visible in these latitudes. The following phenomena of the satellites occur while Jupiter is more than 8° above and the Sun 8° below the horizon. On the 1st a transit ingress of the third satellite at 8h. 39m. P.M., and its egress at 11h. 7m. P.M. On the 3rd a transit ingress of the first satellite at 9h. 2m. P.M.; of its shadow at 10h. 23m. P.M.; and a transit egress of the satellite at 11h. 16m. P.M. On the 4th an occultation disappearance of the first satellite at 6h. 22m. P.M., and its reappearance from eclipse at 9h. 54m. 15s. P.M. On the 5th a transit egress of the first satellite at 5h. 45m. P.M.; of its shadow at 7h. 5m. P.M.; and an occultation disappearance of the second satellite at 9h. 30m. P.M. On the 6th an eclipse reappearance of the third satellite at 6h. 9m. 53s. P.M. On the 7th a transit egress of the second satellite at 7h. 13m. P.M.; a transit ingress of its shadow at 7h. 23m. P.M., and a transit egress of the shadow at 9h. 51m. P.M. On the 10th a transit ingress of the first satellite at 10h. 58m. P.M. On the 11th an occultation disappearance of the first satellite at 8h. 18m. P.M. On the 12th a transit ingress of the first satellite at 5h. 27m. P.M.; of its shadow at 6h. 48m. P.M.; a transit egress of the satellite at 7h. 41m. P.M., and its shadow at 9h. 1m. P.M. On the 13th an eclipse reappearance of the first satellite at 6h. 18m. 58s. P.M.; an eclipse disappearance of the third satellite at 8h. 23m. 13s. P.M., and its reappearance at 10h. 11m. 39s. P.M. On the 14th a transit ingress of the second satellite at 7h. 18m. P.M.; its egress at 9h. 52m. P.M.; and the transit ingress of its

shadow at 10h. 2m. P.M. On the 16th an eclipse reappearance of the second satellite at 6h. 34m. 31s. P.M. On the 18th an occultation disappearance of the first satellite at 10h. 15m. P.M. On the 19th a transit ingress of the first satellite at 7h. 24m. P.M.; of its shadow at 8h. 44m. P.M.; and a transit egress of the satellite at 9h. 38m. P.M. On the 20th an occultation disappearance of the third satellite at 6h. 46m. P.M.; an eclipse reappearance of the first satellite at 8h. 14m. 44s. P.M.; and an occultation reappearance of the third satellite at 9h. 16m. P.M. On the 21st a transit egress of the shadow of the first satellite at 5h. 25m. P.M., and a transit ingress of the second satellite at 9h. 59m. P.M. On the 23rd an occultation reappearance of the second satellite at 6h. 43m. P.M.; its eclipse disappearance at 6h. 51m. 29s. P.M.; and its eclipse reappearance at 9h. 11m. 39s. P.M. On the 26th a transit ingress of the first satellite at 9h. 22m. P.M. On the 27th an occultation disappearance of the first satellite at 6h. 43m. P.M., and its reappearance from eclipse at 10h. 10m. 26s. P.M. On the 28th a transit egress of the first satellite at 6h. 6m. P.M., and a transit egress of its shadow at 7h. 21m. P.M. On the 30th an occultation disappearance of the second satellite at 6h. 51m. P.M.; an occultation reappearance at 9h. 25m. P.M., and an eclipse disappearance of the satellite at 9h. 29m. 1s. P.M. A transit ingress of the shadow of the third satellite at 6h. 28m. P.M., and a transit egress at 8h. 28m. P.M. on the 31st. The following are the times of superior and inferior conjunctions of the fourth satellite:—Superior, January 9th, 4h. 2m. P.M.; January 26th, 10h. 56m. A.M. Inferior, January 18th, 3h. 14m. A.M. Jupiter is in quadrature with the Sun on the 6th.

Saturn is an evening star for the greater part of the month, rising on the 1st at 0h. 15m. A.M., with a southern declination of 2° 43′, and an apparent diameter of 16·4″ (the major axis of the ring system being 39½″ in diameter and the minor 6″). On the 31st he rises at 10h. 14m. P.M., with a southern declination of 2° 41′, and an apparent diameter of 17·3″ (the major axis of the ring system being 41½″ in diameter, and the minor 6½″). He is in quadrature with the Sun on the 2nd. Titan is at his greatest eastern elongation at 4·7h. P.M. on the 5th, and at 3·8h. P.M. on the 21st. Iapetus is in inferior conjunction at 1·9m. A.M. on the 4th, and at his greatest western elongation at 10·7h. on the 24th. Saturn is almost stationary in Virgo during the month, in a region almost destitute of naked-eye stars.

Uranus does not rise till an hour after midnight at the end of January.

Neptune is excellently placed for observation, rising as he does at 1h. 48m. P.M. on the 1st, with a northern declination of 20° 15′, and an apparent diameter of 2·7″. On the 31st he rises at 11h. 48m. A.M., with a northern declination of 20° 12′. During the month he describes a very small retrograde path to the N.W. of the 5¾ magnitude star Weisse's Bessel^3, ivh. 650. A map of the small stars near his path will be found in the *English Mechanic* for October 28th, 1892.

January is a favourable month for shooting stars, the most noted shower being that of the *Quadrantids*, the radiant point being in R.A. 9h. 12m., and 53° north declination, the greatest display being visible during the morning hours of January 1st to 3rd.

The Moon is full at 1h. 41m. P.M. on the 2nd; enters her last quarter at 10h. 28m. P.M. on the 9th; is new at 1h. 28m. P.M. on the 18th; and enters her last quarter at 6h. 27m. A.M. on the 25th. She is in apogee at 7h. A.M. on the 12th (distance from the earth 251,600 miles), and in perigee at 2h. A.M. on the 28th (distance from the earth 229,360 miles).

Chess Column.

By C. D. LOCOCK, B.A.Oxon.

ALL COMMUNICATIONS for this column should be addressed to the "CHESS EDITOR, *Knowledge Office*," and posted before the 10th of each month.

Solution of December Problem:—

1. R to B6, and mates next move.

CORRECT SOLUTIONS received from J. C. Knocker, H. S. Brandreth, and Alpha.

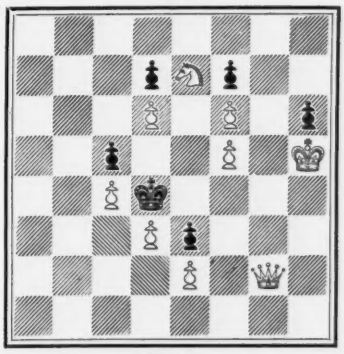
J. C. Knocker.—Your solution is perfectly intelligible.

J. N. Babson (Montreal).—Thanks for the pamphlet.

PROBLEM.

By J. N. BABSON.

BLACK.



WHITE.

White to play, and mate in three moves.

The above elegant composition is taken from a pamphlet entitled "Pleasant Hours with the Chess Board," being a selection of problems by Mr. Joseph Ney Babson, of Montreal. The author intends to publish a selection of three hundred of his problems of all kinds during the winter. The price is two dollars. Subscriptions should be sent to J. N. Babson, P.O. Box 127, Montreal, Canada. The pamphlet referred to contains a few specimens of the composer's skill. One or two appear to be incorrectly printed. The problem given above is described as "a neat little mate in three for those who do not care to wade into difficulties." It is not, however, quite so simple as it looks.

The following is one of the two games played by telephone on December 17th, between the British Chess Club, London, and the Liverpool Chess Club.

QUEEN'S FIANCHETTO DEFENCE.

WHITE (British C. C.).	BLACK (Liverpool C. C.).
1. P to K4	1. P to QKt3 (*a*)
2. P to Q4	2. B to Kt2
3. B to Q3	3. Kt to QB3
4. P to Q5 (*b*)	4. Kt to K4
5. B to K2	5. P to K3
6. P to QB4	6. P × P
7. BP takes P	7. Kt to KB3
8. Kt to QB3	8. B to Kt5
9. Q to Q4	9. Q to K2
10. B to KB4 (*c*)	10. B × Ktch
11. P × B	11. P to Q3
12. B to Kt5ch.	12. Kt (K4) to Q2
13. Castles (*d*)	13. Castles QR
14. P to B3	14. Kt to B4
15. B to Kt5	15. P to QR3
16. B to QB4	16. P to R3

17. B × Kt	17. P × B
18. P to Kt4 (*e*)	18. K to Ktsq
19. Kt to K2	19. Q to K4
20. Q to Q2 (*f*)	20. P to KR4
21. P × P (*g*)	21. R × P
22. Kt to Kt3	22. R to R2
23. QR to Ksq	23. QR to Rsq
24. R to K2	24. R to R5
25. Kt to B5	25. R to B5
26. Kt to Q4	26. P to Kt4
27. B to Kt3	27. R to R4
28. R to Ktsq	28. R to Kt4
29. R (K2) to Kt2	29. K to Rsq (*h*)
30. B to Qsq	30. R × R
31. R × R	31. R to R5
32. B to B2 (*i*)	32. K to R2
33. Q to B2	33. Q to B5ch
34. K to Kt2	34. B to Bsq
35. Kt to K2 (*j*)	35. Q to R3
36. Q to Kt3	36. K to Kt2
37. Q to B2	37. B to R6
38. R to Kt8	38. B to Q2
39. R to Kt2	Drawn Game (*k*).

NOTES.

(*a*) From which it was conjectured by the London players that Mr. Owen was at the Liverpool board.

(*b*) Premature perhaps; the Pawn should be quietly defended.

(*c*) To prevent B to QB4. If Black reply 10. Kt to Kt3, White intended to continue with 11. B to KKt5.

(*d*) A necessary consequence of their previous move, which was played without due consideration. Two Pawns being threatened, castling was compulsory.

(*e*) White having attained their object in doubling the adverse Pawns (apparently the only thing they had to play for) proceed to ensure their continuance in the double state. But they overlooked something, as will be seen later on (*vide* Note *g*).

(*f*) Better than 20. Q to K3, because of the reply 20. QR to Ksq, threatening to win a Pawn by 21. P to Kt4; 22. B to Kt3, Kt × B; 23. P × Kt, B × P, etc.

(*g*) If now 21. P to KR3, Black wins by 21. P × P; 22. RP × P, R × R; 23. R × R, Kt × P! White are now virtually on the defensive for a few moves, but it is nothing very serious, provided that they are not tempted to weaken their centre by P to KB4.

(*h*) Both sides were pressed for time about here.

(*i*) A necessary preliminary to their next move.

(*j*) With a view to a sortie of the Queen *via* Kt3 to Kt8, but they find afterwards that there is nothing to be gained by this process. Another line of play was 35. Kt to Kt3, K to Kt3; 36. P to R4, P × P; 37. Kt × Kt, P × Kt; 38. B × P, with the advantage. The London players had analyzed this variation three moves previously, when the Black Bishop stood at Kt2, and perceived that 38. B × P would be answered by 38. . . . B × QP. They failed to notice afterwards that Black's 34th move did away with this objection.

(*k*) White were now perforce content to accept the draw which they had refused a few moves back.

[The score of the above game is from the *Standard*; we believe, however, that it is not quite correct in the order of some of the moves.]

CHESS INTELLIGENCE.

The return match by telephone between the Liverpool Chess Club and the British Chess Club, London, took place on December 17th. As in the previous match, two consultation games were played. At one board Messrs. Blumberg, Cairns, Ferguson, and Wellington, on the part of Liverpool, opposed Messrs. Heppell, Hoffer, Lord, and Trenchard of London. Liverpool played the Ruy Lopez, which was defended regularly, and resulted in equality. The London players, in endeavouring to force the draw, injudiciously allowed exchanges which resulted in Bishops being left of opposite colours, a fact which speedily decided the game in favour of Liverpool. Evidently the ancient superstition concerning the invariable drawing tendency of Bishops of opposite colours still lingers in the minds of first-class players.

In the other game Liverpool was represented by Rev. J. Owen, Messrs. A. Dod, Kaizer, and Dr. Sugden; the London players being Messrs. Donisthorpe, Guest, Hirsch, and Locock. This game, which resulted in a draw after six hours' play, is given above. The match resulted as last year in a victory for Liverpool. Without in any way wishing to detract from the merits of this result, it may be mentioned that the London players were much disturbed by their unquiet surroundings, and wasted much valuable time in refuting the suggestions of certain irresponsible spectators. We understand that they manage these things better in Liverpool.

On November 28th, Cambridge University (past and present) defeated a team representing the British Chess Club by 6½ games to 2½. The London Club was not very strongly represented throughout.

The Handicap Tournament at the British Chess Club resulted in the victory of Mr. Trenchard, who defeated Mr. Donisthorpe, the winner of the other section, after losing the first game and drawing the second.

Surrey and Sussex played a match, 20 a side, on November 28th, at Brighton, the result being a tie.

On December 10th, the British Chess Club, who are unusually active this season, defeated the Athenæum Chess Club by 6 games to 4.

There will be an Amateur Tournament at Cambridge, commencing on January 3rd. The entrance fee is two guineas. Applications should be made immediately to the Rev. A. B. Skipworth, Tetford Rectory, Horncastle.

Mr. C. T. Blanshard is bringing out a translation of Dufresne's "Examples of Chess Master-play," a collection of 74 match-games played in the years 1887-90. The notation will be English, and the price 2s. Mr. W. W. Morgan is the publisher.

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